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ANNUAL REPORT

and

PROCEEDINGS

of the

Canadian Cement and Concrete Association

at the

SECOND ANNUAL MEETING AND CONVENTION

held at

London, Ont.

MARCH 28th to APRIL 1st.,
1910.

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Contents.

Executive 1909-1910 5

Executive 1910-1911 6

Programme of the Convention, 1910 7-8

Papers :

THE PRESIDENT'S ANNUAL ADDRESS
Peter Gillespie 9

CONCRETE CONSTRUCTION
C. B. Smith 14

CONCRETE CONSTRUCTION IN THE COUNTRY
Ernest Wilby 21

WATERPROOFING CONCRETE
R. A. Plumb 26

USE OF CEMENT IN ARCHITECTURE
F. S. Baker 36

WHAT CONCRETE MEANS TO THE FARMER
Percy H. Wilson 40

CONCRETE BRIDGES
A. W. Connor 49

AN ANALYSIS OF CONCRETE BRIDGE FAILURES
C. R. Young 54

THE ENGINEER AND THE FINISHED WORK
A. W. Campbell 68

THE CONSTRUCTION OF CONCRETE HIGHWAY BRIDGES
Chas. Talbot 73

CONCRETE PAVEMENTS
James Pearson 77

SOME EXPERIMENTS WITH CEMENT TILE
W. H. Day 82

THE HARDENING OF PORTLAND CEMENT
A. G. Larson 88

THE COMMERCIAL ASPECT OF REINFORCED CONCRETE IN CANADA
Gustave Kahn 96

WHAT THE CONCRETE BLOCK MEANS TO CANADA
J. Augustine Smith 102

EXECUTIVE 1909-1910.

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Lecturer in Theory of Construction, University of Toronto.

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A. E. UREN,
Editor "Cement and Concrete Review," Toronto, Ont.

EXECUTIVE 1910-1911.

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A. E. UREN,
Editor "Cement and Concrete Review," Toronto, Ont.

C. R. YOUNG,
Barber and Young, Bridge and Structural Engineer, Toronto, Ont.

Programme

of the

Second Annual Convention.

Monday, March 28th, 1910

7.30 o'clock p. m.

FORMAL OPENING OF THE EXHIBITION.

By Mayor Beattie, of London, Ont.

RECEPTION of the Citizens of London by the Officers and Members of the Association.

Tuesday, March 29th

2.30 o'clock p. m.

ANNUAL ADDRESS BY THE PRESIDENT.

Peter Gillespie, Lecturer in Theory of Construction, University of Toronto.

CONCRETE CONSTRUCTION.

Cecil B. Smith, of Smith, Kerry and Chace, Consulting Engineers, Toronto, Winnipeg, and Calgary.

CONCRETE CONSTRUCTION IN THE COUNTRY.

Ernest Wilby, Architect, Detroit, Mich.

(*Paper read by Secretary.*)

WATERPROOFING OF CONCRETE.

R. A. Plumb, Chemist, Detroit, Mich.

8.00 o'clock p. m.

THE USE OF CEMENT IN ARCHITECTURE.

F. S. Baker, President, Royal Architectural Institute of Canada, Toronto, Ont.

WHAT CONCRETE MEANS TO THE FARMER.

Percy H. Wilson, Secretary of the Association of American Portland Cement Manufacturers, Philadelphia, Pa.

INEXPENSIVE HOMES OF CONCRETE.

Milton Dana Morrill, Architect, Washington, D.C.

(*Paper read by the Secretary.*)

Wednesday, March 30th

10.30 o'clock a. m.

DISCUSSION OF PROPOSED STANDARD SPECIFICATIONS.

2.30 o'clock p. m.

CONCRETE BRIDGES.

A. W. Connor, of Bowman and Connor, Consulting Engineers, Toronto, Ont.

AN ANALYSIS OF CONCRETE BRIDGE FAILURES.

C. R. Young, of Barber and Young, Bridge and Structural Engineers, Toronto, Ont.

CONCRETE ROADWAY CONSTRUCTION.

C. W. Boynton, Chief Inspecting Engineer, Universal Portland Cement Co., Chicago, Ill.

8.00 o'clock p. m.

THE ENGINEER AND THE FINISHED WORK.

A. W. Campbell, Deputy Minister of Railways and Canals, Ottawa, Ont.

THE CONSTRUCTION OF CONCRETE HIGHWAY BRIDGES.

Chas. Talbot, County Engineer for County of Middlesex, London, Ont.

CONCRETE PAVEMENTS.

James Pearson, President, The Constructing and Paving Co., Toronto, Ont.

Thursday, March 31st

10.30 o'clock a. m.

ANNUAL MEETING OF MEMBERS.

Election of Officers and Reception of Report of Executive.

2.30 o'clock p. m.

CONCRETE IN EUROPE.

Richard L. Humphrey, President, National Association of Cement Users, and Director, United States Structural Materials Testing Laboratories, Pittsburg, Pa.

SOME EXPERIMENTS WITH CEMENT TILE.

W. H. Day, Professor of Physics, Ontario Agricultural College, Guelph, Ont.

THE USES OF CONCRETE ON THE FARM.

Philip L. Wormeley, Testing Engineer, Office of Public Roads, United States Department of Agriculture, Washington, D.C.

THE HARDENING OF PORTLAND CEMENT.

A. G. Larson, Chemist, The Grey and Bruce Portland Cement Co., Owen Sound, Ont.

8.00 o'clock p. m.

THE ANNUAL DINNER OF THE ASSOCIATION.

The Tecumseh Hotel.

Friday, April 1st

2.30 o'clock p. m.

GOVERNMENT TESTING LABORATORIES.

Richard L. Humphrey, President, National Association of Cement Users, and Director, United States Structural Materials Testing Laboratories, Pittsburg, Pa.

THE COMMERCIAL ASPECT OF REINFORCED CONCRETE IN CANADA.

Gustave Kahn, General Sales Manager, Trussed Concrete Steel Company of Canada, Toronto, Ont.

WHAT THE CONCRETE BLOCK MEANS TO CANADA.

J. Augustine Smith, Secretary and Sales Manager, Ideal Concrete Machinery Co., South Bend, Indiana, U.S.A.

CONCRETE FROM THE CONTRACTOR'S STANDPOINT.

D. C. Raymond, Vice-President, Bishop Construction Co., Montreal and Toronto.

THE PRESIDENT'S ANNUAL ADDRESS.

THE PRESENT STATUS OF THE ASSOCIATION—THE NECESSITY FOR FIREPROOF CONSTRUCTION.

BY PETER GILLESPIE.

The Canadian Cement and Concrete Association has completed the second year of its history with an outlook for usefulness which is undoubtedly brighter than it was a year ago. Its membership is larger; its name and aims are more widely known; its financial status is more comfortable and in a few particulars it has learned wisdom through mistakes of the past. As anticipated in my opening remarks to you last March, a permanent secretary has been appointed, to whom has been delegated the clerical work connected with the Association. The new regime is proving very satisfactory, and I think that this will be a means to extending its influence and work. A Committee on Standard Specifications has been at work and will report to you during the week on the results of its labors. It is felt that by issuing Standard Specifications which are up to date, but also sufficiently conservative to meet the approval of moderate people, the Association will be doing something to endorse safe and economical construction in concrete.

Regarding the attitude of the Canadian Cement and Concrete Association toward other building materials, I have only a word to say. While it stands for the dissemination of authentic information regarding the uses of a comparatively new material, for the encouragement of whatever in cement construction is safe, economical and artistic, and for the elimination of whatever is unsafe, wasteful and unsightly, it does not decry nor condemn any other legitimate building material. It recognizes that others have claims and advantages of their own and does not advocate cement construction where another material is manifestly superior for the special situation under consideration. It recognizes also that steel and concrete and clay products and wood make, on occasions, most excellent structural combinations, and feels no enmity nor jealousy towards any of them.

It has been pointed out that human progress from pioneer conditions always divides itself into three noteworthy stages. There are, first, the period of individual enterprise involving the conquest of the wilderness and making for the benefit of the *man*; second, the period of collective enterprise making for the benefit of *communities*, or of the individuals constituting them; third, the period of co-operative enterprise, largely altruistic, for the advantage of the *nation* and for succeeding generations as well as those of the present. This last is the era upon which we are now entering, an era when an endeavor to use wisely, to avoid unnecessary waste and to look to the requirements of the future is being made. As a sign of the times, we have Commissions on the Conservation of Natural Resources. It is to a recognition by the present generation of its responsibility to posterity, that these important commissions of inquiry in the United States and Canada owe their beginning. "The duty of man to man, on which the integrity of nations must rest, is no higher than the duty of each generation to the next; and the obligation of the nation to each actual citizen is no more sacred than the obligation to the citizen to be, who, in turn, must bear the nation's duties and responsibilities." It is only of recent years that the attention of people in the New World has been drawn to the fact that the natural resources of this continent are not inexhaustible and that if the duty of the present, to succeeding generations is to be faithfully discharged, some methods of conserving these assets must be devised. The most reprehensible of all waste is destruction and the most destructive of all agencies is fire, and to the extent of its ravages in this country at the present time, to a comparison of our own country's fire loss with that of other lands, and to means for minimizing this appalling waste, I invite your attention for a few minutes to-day.

A report of the United States Geological Survey, recently to hand, affirms that during the year 1907, the per capita loss in the United States due to the destruction of buildings and their contents by fire was $2.51, while the average corresponding per capita loss in Austria, Denmark, France, Germany, Italy and Switzerland during various periods from 1898 to 1904 was only 33 cents, an amount only one-eighth that quoted for the United States of America. It must also be remembered that to the actual per capita loss as given above, viz., $2.51, must be added a number of items indirectly, if not directly, chargeable to the fire fiend. Premiums are paid to fire insurance companies obviously very much in excess of the compensation for fire losses returned to the insured; fire fighting equipment and a water distributing system must be installed and maintained at an expense very much in excess of what would be required for purely industrial and domestic necessities. These the statistician has estimated as follows:

Excess of premiums paid over amount of losses returned, per capita	$1.71
Maintenance of waterworks, chargeable to fire service exclusively, per capita	.33
Maintenance of public fire departments, per capita	.57
Maintenance of private fire protection, per capita	.21

This makes a total annual per capita tax of $5.35 and represents an aggregate cost to the public of the United States of 456 millions of dollars, an amount the magnitude of which it is exceedingly difficult to comprehend. If through any cause it were possible to reduce the actual fire loss in the United States to a figure comparable with what prevails in the countries of continental Europe, there would be a proportionate reduction in related and accessory items as well, which, it is estimated would reduce the aggregate loss through fire to ninety millions of dollars, which would mean a saving to the Republic of 366 millions. In consequence, it would appear that the United States is paying annually a preventable tax sufficient to construct a Panama Canal. For the year 1907 the total value of buildings erected in the Republic was conservatively estimated at $1,000,000,000 and from what has been said above, it is seen that a loss by fire equal to practically half the value of the buildings constructed, was suffered by the American people. This is a loss that no system of account keeping or no method of clever logic can conceal. Destruction by fire is absolute and irreparable and insurance when paid to the owner, serves only to distribute the loss among the whole body of the insured. This state of affairs is truly appalling and it is a striking wonder that economists have given so little attention to the evil and its remedy.

The Monetary Times of January 8, 1910, reports the aggregate loss in Canada due to fire during the year 1909, as $18,905,000, with a total loss of life of 219. The daily press report of a fire was first accepted by this journal and then enquiries were addressed personally to the owner and occupant of the property destroyed. In this way fairly authentic information, regarding the magnitude of the loss was obtained. An actual fire loss of one and three-quarter millions of dollars per month in Canada must give us pause. This is equivalent to a per capita loss of $2.70, seven per cent. greater than that reported by the United States, twenty-three times as large as that reported for Italy, six times as large as that reported for Germany, and nine times as large as that reported for France. Assuming that for Canada, the accessory and related losses due to insurance, fire protection, etc., are of the same order as in the neighboring Republic, Canada's sacrifice to the fire monster, directly and indirectly, will approximate the enormous total of $40,000,000 per year. This amount is four times the yearly interest on Canada's national debt, is nearly equal to the total annual revenue from duties on imports into Canada, is seven times as large as the entire annual expenditure for postal facilities in this country, is twice as great as the annual expenditure by the people of the country for the maintenance of churches and clergy of all denominations and is sufficient to construct four Dreadnoughts annually. In addition to this, there were sacrificed last year, four lives per week for every week of the year, a number almost large enough to place a victim's skull on every mile-post between Buffalo and Detroit. On this side of the water we view with alarm the manner in which the European powers are breaking the backs of their taxpayers in order to render their armaments on land and sea more and more formidable, and we are, sometimes, in consequence led to doubt the real progress of civilization, not thinking perhaps that our own prodigality in the matter of destruction by fire must arouse in them a feeling of wonderment at the folly of the so-called progressive American people.

The cause of such destruction is not far to seek. Our buildings, many of them, are constructed of most inflammable materials, and although they may be protected by the most perfect fire-fighting appliances that ingenuity can devise, conflagrations are inevitable. The disastrous Toronto and Baltimore fires of 1904, the San Francisco calamity of 1906, and the Collinwood School House tragedy and the conflagration in Chelsea, Mass., in 1908, are still fresh in the people's minds, and it is safe to say that had fireproof construction, as to-day understood, prevailed generally, these unfortunate disasters would either have never occurred or the evils attending them would have been very much less than they actually were. The alarming feature of the entire situation is that similar calamities may occur any day in any city in Canada or the United States.

In America, combustible building materials are employed to an extent that would not be tolerated in Europe. Older in the world's history than America, these nations have developed a wisdom in construction, in comparison with which America suffers greatly. In many European cities, the erection of wooden buildings is prohibited and the use of inflammable material in construction is so rigidly regulated and overseen that fires are confined in practically every instance to the building in which they originated. It is manifest from the results that the consequences of European paternal government are not at all disadvantageous.

A report from a branch of the Government service at Washington, D.C., has this to say:—"The timber supply of the United States is rapidly approaching exhaustion and unless means are taken to limit the waste (a great deal of it through fires) and replenish the supply through reforestation, the timber resources of the country will be exhausted within the next quarter of a century. The known supplies of high-grade iron in this country, estimated at more than 4,788,000,000 tons, cannot be expected to last beyond the middle of this century unless the present increasing rate of consumption is curtailed. There are in addition about 75,000,000,000 tons of low-grade iron ore which will undoubtedly be used to some extent as the price of iron advances. The supplies of stone, sand, gravel, clay, cement, lime and slate are practically inexhaustible and as the supplies of timber and iron are depleted and the prices of these are increased it is evident that the United States must turn to concrete-making materials, clay products and building stone as substitutes for wood and iron.'' Continuing, the same report asserts that ''The mineral materials available for structural purposes may be divided into two classes—(1) iron, steel, copper, nickel and their manufactures, the supplies of which are limited and which are themselves subject to destruction through weathering, fire and other causes; (2) stone, clay products and cement and concrete manufactures, which are less subject to destructive agencies and the supplies of which are practically inexhaustible.

. ''In building and construction work the substitution of the materials of the second group for the more commonly used wood and metal manufactures should be encouraged as having an important influence on the preservation of the supplies of the more perishable and scarcer materials. The use of building stone and clay and cement products in this country had been restricted by competition with the much cheaper wood products and the more easily fabricated and more available metal products. Improved methods of preparing the raw materials for use in building construction are, however, rapidly diminishing the difference in cost, and careful investigation as to their structural qualities and the more suitable structural forms would have an important influence in further reducing this difference in cost and in enlarging the use of the more permanent materials.'' It is manifest from the above that those materials which occur in almost inexhaustible quantities and which, when fabricated into structural forms, are least susceptible to destructive agencies, must be looked to to save the situation. They constitute the really fireproof building materials as has been attested by numerous severe trials. Building regulations on this continent, however, have been very much to blame in their failure to compel, or at least encourage their use. They have permitted the erection of structures either of inflammable materials or of incombustible materials in such a way that when a fire occurs in the contents of a building it is not usually confined to that building. Our fire protection appliances are probably as modern on this continent as elsewhere, so that it seems conclusive that to insist on the use of fireproof building materials in the first place, and in the second to scrutinze carefully the method of using them so that fires when they do occur, will be properly confined, will be the remedy. It is exceedingly poor economy to sacrifice to-morrow the accumulated wealth of years of labor for the immediate convenience and needs of to-day.

Papers.

[*This Association is not responsible as a body for the opinions expressed in its Papers by Authors.*]

CONCRETE CONSTRUCTION.

BY CECIL B. SMITH.

Various economic causes have led to the extended modern uses of concrete, but beautification has been an afterthought and is still an effort, giving modest results. Taking up a consideration of the subject from the nineteenth century only, we have all noted the rapid growth in the last twenty years, the spreading into various channels, applications ranging from foundations, seawalls, docks and other heavy masses to lighter forms such as graceful arched bridges with ornamental surfacings and fireproof reinforced concrete offices and factories, the moulded block may yet rival the stonecutter's art and the clay-worker's skill.

The natural question at once presents itself, will the present structures endure as has the work of the ancient clay-potter or monkish architect, and will the state of the art grow to higher flights and will our children's children see our handiwork?

The motive of this paper is to discuss broadly the essentials of construction and constitution as at present understood.

The treatment must properly start with the question of artificiality, its dangers, its pitfalls and its advantages, all of which is too often lost sight of. From the instant of quarry blasting until the structure is completed, human agencies are at work, grinding, burning grinding, mixing, crushing, tamping, trowelling, until presto! an intensely human creation is on view and nature has been momentarily conquered.

Cement is essentially a human product and therefore imperfect and, what is very important and noticeable is that it is varying year by year in its characteristics, moulded at times by true skill and science or through the demands, often mistaken, of those who use or control the use of the material.

At present it is considered in America that a cement manufactured from ground quarry rock of certain *average* ingredients, blended with a second material to give correct chemical proportions, is the cheapest product and is quite satisfactory, not only to the trade but to the skilled engineer and scientist. This is a grave question, however: the highly limed, highly burned, finely ground clinker gives a cement which, when deadened by gypsum, will prove by all the gods (laboratories) to be fit to meet the specific tests now prescribed, but high tensile strength at one week proves nothing except that the product matures early. The writer is painfully aware of the present tendencies; the engineer thinks he is leading, but he is being pushed along by the manufacturers into desperate courses in a vain attempt to control the product to his satisfaction. The writer has been testing and using various cements in large quantities for twenty-years and also spent five years studying the characteristics of cement, and he is far from satisfied with present methods and usage.

Boiling tests at the best are irrational, arbitrary and inconclusive and hardly safe grounds for absolute rejection. Hot water tests are less severe but of the same inclusive order, and the only just and safe method apparently is to wait a month and observe the action of natural conditions. Cement is shipped too green, used too soon, and not given a fair chance, so keen is present-day commercialism. To be specific, gypsum dosing to regulate the time of setting and to disguise the presence of free lime is too prevalent, and early shipments of cement still containing a free alumina, hot and variable in nature, is not uncommon practice. Upon the cement arriving at the works there is often no time to wait, and either without tests or only with hurried ones, the cement is put into service if the sieving, boiling, specific gravity and one-week tests are acceptable; but after results prove that in many cases the mortar in six months' time will show brittleness and unsoundness, and will in due course disintegrate. The view is here expressed that present specifications demand too much strength at early tests, but not enough by way of uniformity, soundness and ultimate toughness, and it would be well to consider the advisability of adopting the British custom of airing the cement before use, which may be done by the user or more rationally and economically by the manufacturer. By suitable arrangements the cement might be thoroughly aired and cooled and the customer could well afford to pay the extra price for a cement proven to have been properly aged and aired before shipment; by such methods, less gypsum would be used and a sound product assured, and again, something further is wanted in the way of being able to secure a cement at a certain time of year and for a certain use which has a certain time of setting to suit the circumstances. The Canada Cement Company having control of so many mills and having a highly skilled organization can effect this, and I trust will do so when it becomes evident that variation in time of set is a marketable quality.

We all read year by year the text-book views and ordinary specifications as to aggregates, and no doubt sound knowledge on this important question is becoming more widespread, but it must be clearly kept in mind that laboratory sand and pit sand are different products.

Tests in laboratory are comparative, relative and protective only, but practice demands that the sand, gravel or broken stone most convenient or cheapest be made use of if possible, and it becomes necessary for a practical man to size up the local situation and take action.

Speaking generally, a run of crushed rock is suitable for heavy concrete unless exceptional strength is required, but care must be taken that the design of storage bins is such as to prevent a separation of the larger pieces which, rolling towards the outlet, will give a variable product. To determine the proper proportion of sand for the concrete, the average percentage of voids in the crushed rock should be determined and a slight excess of sand used, say 10 per cent. If the rock used is sound limestone, granite or trap, the finer particles from the crusher represent some of the required sand, but in some cases the amount of dust produced necessitates screening.

The writer is not in favor of the use of sand rolls to make artificial sand, as the result from the grinding of most rocks is a mixture of dust and slivers, and the concrete therefrom weak, variable and sloppy. The constitution of gravel may make it an ideal material for straight concrete, but in most cases the variation is so great as to warrant screening and reproportioning; however, a well made gravel concrete is usually heavier than a rock concrete, although not usually as strong. The variations in quality of sand make it a difficult subject to discuss. Everyone knows what a good sand should be, namely, of blended sizes, angular grained, clean quartz and, for concrete, to be rather coarse so as to economize in the use of cement; but usually one must accept an article only approximating to the ideal and a fine, round grained sand with some clay or loam must often be made the best of. Of course if it is too poor it must be washed, but the usual course is to select the best available and add more or less cement as may in the user's judgment be required to properly coat the particles, for which again a determination of the voids in the sand is advisable and a 10 per cent. excess of cement used.

Since the concrete ingredients have been determined upon, we come again to the question of human agency. The writer remembers well in building a large undertaking, that some months after the concrete had been laid a soft spot was found, and upon careful investigation it was determined that a mass of about twenty cubic feet had absolutely no cement in it, and it was carefully dug out from the side of the wall and good concrete packed into the hole. It is evident that the inspector and men at the mechanical mixer had failed to put in any cement.

In practice, a suitable arrangement is to have a young student at the mixer to watch the assembly of materials and mixing, and a veteran builder at the wall to supervise the placing of the mixtures; but even with ample inspection, the human equation must be reckoned with.

It would not be suitable in this discussion to rehearse in detail the ordinary routine of mixing and placing concrete; we all realize the numerous sources of error, and the necessity for constant and intelligent supervision. It is proposed to discuss certain special features and incidents arising from a rather varied experience.

Assuming that the concrete is properly constituted and placed, undoubtedly the most essential feature is the character of the foundation, for whilst concrete, owing to its monolithic nature, will span over small deficiencies in foundation, yet the limit is quickly reached. If, for instance, the structure is a large arched waterway under railway embankments, this feature becomes vital, and the writer has vividly before him disasters arising from upward pressure, between the two main walls, causing a complete wrecking of the structure. To meet this, future structures were placed on piling and heavy reinforcement added, and still disaster, less severe than formerly, but still serious, occurred, and it was the evident deduction from these experiences that the only method of meeting the condition of deep and unstable clay foundations is to build the arched waterway having a heavy superimposed load, with an inverted arch to completely meet the upward thrusts, and this has been found satisfactory. Another feature of design, often serious, is the special strains coming on the head walls and wings of such structures, and from the use of many types and after several disasters, the writer is of the opinion that when dealing with unstable materials, no amount of reinforcement or mass will fully meet the terrific stresses applied by sliding embankments; the only safe design is to carry the barrel of the arch forward and omit parapet and wings entirely. These remarks do not apply to ordinary dry materials placed by teams or wagons, but to train-filled embankments made from unstable materials. In a recent train-filling experience the whole valley was liable to be distorted by the superimposed loads placed on the clay bottom, and the chief engineer successfully prevented local distortion by a very heavy treatment of cross-logging placed in the embankment after it was partly made. This saved the arched culvert from destruction. The writer also calls attention to the undue burden placed on concrete abutments by attempting to shorten the spans, and it is impressed on him that the proper course to pursue is to lengthen the spans and reduce the abutments to mere bridge seats. The equilibrium of the hillside will thus be preserved.

The placing of concrete in cold weather is a much discussed subject, but it has no real limits except expense. To be specific, the writer has placed concrete river piers in February, with temperature 20 degrees to 40 degrees below zero, with perfect and economical results, as follows:—Hot sand, stone and water, no salt, and the structure protected by a large tent in which a stove maintained a reasonable temperature when aided by the heat of chemical action during the process of setting. Again, the concrete has been placed at Point du Bois, Winnipeg River, all winter under a huge shed warmed by stoves; the sand is in large mass and is heated by a buried steam pipe freely flowing, the economy and results are quite satisfactory. On the other hand, the writer cannot advocate the placing of small masses without adequate protection or the placing in cold water in small batches; the chances are that the setting action will be suspended. The writer knows of several instances where concrete placed both under the water and in open air in cold weather in even large masses has not set until the next May or June. The essential thing is to provide enough warmth for a long enough period and to conduct the work continuously; once the crystallization has commenced the danger is passed.

In construction of walls required for water-tightness and for decent finish, the method found most satisfactory is to place a continuous mortar facing three inches to four inches thick of 1 to 1 mortar simultaneously with the placing of the mass concrete; this is not a difficult process when systematized and is the only proper method of obtaining certain and perfect results, and any attempt at spading back the stone from the face of the wall is never perfectly done and is a poor substitute at best for the facing method. To obtain a smooth finish, of course one should use dressed matched forms, but the addition of soft soap swabbed on with a brush will give better results than oil and is not an item of serious expense. When the walls are built in the summer season there is a danger of surface cracking, even if forms are left in to protect the wall from the sun's rays, but this may be avoided by placing a pipe with perforations along the top of the wall and pumping water through, or if less expensive, a hose may be used; but the former is preferable if the work is of an extensive nature, and this treatment should be continued for a fortnight if possible.

One of the least understood questions is that of expansion, and this should be treated from several viewpoints: in the first place, do engineers realize that cement when of the most perfect character and used to form concrete masses skilfully mixed and placed has a certain definite action during the process of crystallization? This has no relationship to soundness or unsoundness, high or low temperature of air or ingredients, methods of placing or density, but is an essential action arising during the natural process of setting and hardening, and the outcome is that contraction in air and expansion under water take place. As concrete is usually placed under water in large masses, and as this expansion can be taken up by internal compressive stress, no harmful results follow. On the other hand the contraction in air has certain results; either this stress is met by reinforcement or by introduction of free joints, or by irregular rupture, and with the free expansion joints we are now concerned.

The writer's practice is to create an absolute cleavage plane approximately every fifty feet unless the wall is shallow and on solid rock; if so situated the joints should be closer or the adhesion of the concrete to the foundation will create local ruptures. When the wall is to contain water under pressure, evidently the joint must be made water-tight, and this may be done either by the use of an oak key or preferably by a concrete prism having an asphalt plug or rod. This is easily introduced and gives an elastic and perfect seal. The prism should be slightly tapered and swabbed with tar or asphalt or covered with paper —the sections of wall may be built either alternate or by stair slips, but the separation may be easily effected either by paper or asphalt as in the case of the key.

Once the hardening process has reached a practical limit, the temperature changes are not serious and may be disregarded, but the initial shrinkage is within limits of one-quarter inch per fifty feet from general observation.

In hurriedly designed structures, particularly buildings, another class of cracking is met with, arising from variation in loading. The writer's observation is that not nearly enough attention is given to this, with the result that loads varying from one to three tons per square foot, may be introduced and the compression of the foundations throws local stress of a serious character onto the lower portion of the structure; of this a vivid instance was where the supports to boilers were carried by columns onto well spread out pedestal foundations not carrying over one and one-half tons per square foot on dry earth rather light in character but as much as ten feet below the natural surface; yet the compression was over one inch and the boiler room floors required relaying.

In conclusion the writer desires to again emphasize one thought chiefly, namely, the artificial character of concrete. The ultimate product has been the result of many human agencies, the production has involved skilled and unskilled labor, the chances of imperfection are many and unceasing vigilance is the price of success; first and foremost, vigilance regarding the cement, a serious effort to secure by the best tests we can devise a sound article; but above all, by the use of cement properly constituted chemically and aged, by taking care of it when it is received, by intelligent proportioning, careful placing, skilful designing, all necessary precautions, and, perhaps, last of all, and not least, by a hesitancy to use it indiscriminately and realizing that we must not trust too implicitly in the permanency of steel reinforcement unless used with great care so as to minimize the chances of corrosion of the steel by the action of ingredients in the concrete itself or by permitting even the faintest percolation of air which will be certain in due course to corrode or rust it. And finally if we are to expect to build a permanent structure and to retain the ultimate respect of the public, it is certain that the treatment of concrete must be natural and not imitative. Each building material has its natural beauty, and the enduring grace of structures made of this material will be achieved when our engineers and architects have by simple, massive treatment educated the public to acquire a concrete taste in no way related to preconceived notions of what is beautiful in similar structures built of stone, brick or wood. Much has already been achieved in this direction, and we may reasonably expect that in due course certain canons of taste in respect to concrete structures will be recognized not only by the profession, but by the general public.

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CONCRETE CONSTRUCTION IN THE COUNTRY.

BY ERNEST WILBY.

Just now all kinds of movements are on foot for the beautifying of our cities. I should like to see a similar movement for the beautifying of our rural districts; the first is a work of great difficulty, the latter, with the aid of concrete, becomes, I believe, very simple.

Usually in obtaining an artistic result, as for example, in cement houses, that result depends on the quality of the design; the designer must be an artist, that is to say, an architect with artistic knowledge and training.

In the field for cement work to which I shall direct your attention, the architect is not essential, a slight knowledge of what constitutes good design would help, but even an entire lack of this knowledge would not destroy, though it might lessen, the beauty of the finished work. Given certain requirements met in the simplest and most practical way by use of concrete, a good result would be obtained as naturally and almost as inevitably as night follows day.

Canada and the United States, being newly settled countries, have had to meet the problem of opening up the land for occupation by rough and ready methods; little thought had been given to so immaterial a thing as beauty. This is especially noticeable in our bridge work; first came the wooden bridge, not altogether without merit, and then in the search for something more durable, that triumph of ingenuity, the modern steel trussed bridge, a tall, attenuated arrangement of struts and wires, beautifully scientific but not by any means scientifically beautiful.

Now, I have no quarrel with the steel bridge for railway work and spans of magnitude, for it is often the only solution, but on our highways for crossing small rivers and streams it is but a poor substitute for the beauty of the arch bridge, and the pity of it is that it is usually placed in a spot where nature, with green foliage, sloping banks and running water, has prepared the setting for a charming picture.

The small steel bridge is an eyesore, and endurable only so long as we cannot replace it with some other form of construction more beautiful, while being practicable and inexpensive; concrete seems to offer us these three advantages.

It is not my purpose, however, to dilate on the practical and economical advantages of concrete construction for bridgework, but on the artistic results which follow its use. Concrete as a material is in harmony with almost any natural setting as soon as it is in place; large surfaces of cement are never monotonous; the texture of the surface gives endless play of light and shade; it also forms a satisfactory background for trees and shrubs; the solidity of the material gives a satisfying appearance of permanence and stability, the absence of which is fatal to all beauty in the steel or wooden bridge.

Ever since the arch was discovered some 2,000 odd years ago, no other form of bridge construction has been invented which, in beauty of form and durability, can compete with it; to appreciate fully how much we lose by not having adopted hitherto this form of bridge construction, we have only to visit England, France, Germany, Italy or Spain; in each of these countries we find the arch bridge of every size and kind used since time immemorial, each one beautiful, a harmonious note in the landscape.

Now at least three parts of this beauty is not the result of design, it comes from using the arch form; the arch is in itself so beautiful that other things matter little. The bridge may be of hewn stone or the most rustic of masonry, may be designed by some talented architect or by some country mason, it may be embellished with sculptured work, mouldings, every kind of enrichment or it may be severely plain, but in no case is it ugly.

We cannot hope to reproduce these bridges in stone, the expense makes that impracticable. In most localities concrete offers the one and only other material, it is a good substitute if used frankly for what it is and not in imitation of stone. While the arch form is applicable to concrete construction, I regard it as essential that the use and shape of the arch be such that no steel reinforcement be needed to give it stability. It must not only *be* strong, but it must *look* strong. For this reason, the elliptical arch is not to be commended; the arch needs only to be semicircular or segmental, in some cases it may be pointed; any of these forms will look well.

It would be preferable to use monolithic construction throughout the bridge. Cement blocks could, however, be used for the arch when they would be more practicable, provided the rock-faced variety were not used. In country districts a high finish is not necessary, a degree of rusticity being more harmonious with the natural surroundings. In this case there would be no objection to simplicity as a safe path to follow: any attempt at decoration is dangerous unless done by a trained designer.

A word about steel reinforcement; there would be no objection to its use for the purpose of giving strength and homogeneity, provided no attempt be made to alter the structural line of the arch; as I said before, the beauty of the bridge depends on the line of the arch which should be similar to a masonry arch, so that it will have the appearance of being self-supporting and of having ample strength to support the weight resting upon it. In a number of cases when the arch bridge has been used in the United States the mistake has been made of giving an excessive rise to the crown of the bridge; a few inches of rise sufficient to overcome the optical effect of sagging is desirable, but should be so slight as to be barely perceptible

To sum up results, we find that the arch bridge is beautiful, that this beauty is not the result of skill in design, but comes from the use of the arch; consequently the road engineer can, without any special knowledge of design, construct a bridge possessing artistic merit. Concrete is the only material at present which can be used for an arch bridge without prohibitive cost; it is satisfactory in texture and color, is easily obtained, gives the required stability of appearance, is permanent, and, provided a capable engineer or superintendent is in charge, local labor can be used in carrying out the work.

That other blot on our landscape, those flimsy, restless constructions of wood we call farm buildings, are much in need of a more permanent and sightly material. Stone is again out of the question on account of cost. Brick also is expensive, and unless a good quality is used, properly laid in cement mortar, and resting on good foundations, it is not permanent; it is also difficult to handle in an artistic way by any but a trained architect and the usual farmer is not likely to employ one.

Occasionally the ambitious farmer, with good intentions but mistaken zeal, has transplanted to the country that type of brick houses beloved of our cheap builders, found in the suburbs of all our large cities, a conglomeration of brick, scroll-sawn wood ornaments, so-called art glass, with a few fussy verandas thrown in for good measure; in the city it is bad enough, but in the country its innate ugliness is made even more apparent by its surroundings.

Now, a farm house and the adjoining buildings should not only serve the purpose for which they are built, but should look the part, should belong to the country, be as much a part of it as the trees, a growth of the soil, not merely resting upon it but a part of it. To accomplish this a solid building material is essential, the structures must have stability, be permanent and look so; added to this the material must harmonize in color and texture with its environment. Concrete will do all this if used with a little judgment.

It is not likely that the artistic value of concrete construction will appeal to the farmer. If he uses it, it will be on account of the low cost, permanence and ease of handling. However, if he can be persuaded to use it for its practical advantages and not be led astray by mistaken desire to imitate stone or to reproduce the features of a town house; if he will only use concrete for what it is, build simply, without any effort to add architectural details, in all likelihood the result will be good.

Farm buildings, from their shape and size, fall naturally into good lines; generally they are long and low with much unbroken wall and roof surface, the windows, doors and other openings are few in number. If to these conditions we add stability, a pleasing wall and roof texture, we then have all the essentials of a good building. This, again, is more than proved by what we find across the ocean; there the farm buildings are good to look at, adding a human touch to the landscape, without marring in any way, its beauty. This is not because they are elaborate, for they are simple in the extreme, nor is it due to intention or design, for their builders had no thought beyond meeting their practical needs; but these buildings have a dignity which comes from honest workmanship and the use of permanent materials. It is to be noted that this material, usually stone, was always a natural product of the vicinity and hence harmonizes perfectly with the face of nature in that district in which it was placed.

One valuable characteristic of concrete is its neutral color, which, in the majority of cases, blends perfectly with nature's color scheme. In concrete for farm buildings I believe the best effect will be obtained by using monolithic construction, not cement blocks, for while the latter is much better than wood and capable of rendering good service, the necessary joints destroy the repose of surface so desirable from an artistic point of view.

All the buildings should be simple in the extreme; let the walls and roof be continuous, and as long as possible, avoiding all unnecessary breaks, keeping all openings some distance from the corners of the building in order to preserve the appearance of stability; the roof-eaves should project some distance, as this not only sheds the rain, protects the walls below from dampness, but gives a shadow of great value in an artistic sense.

If these simple rules are followed, and concrete is used for the walls, and the usual wood shingles for roofs, the combination would result in buildings which fit naturally into the landscape.

A few trees would add greatly to the effect; creepers also could be allowed to grow without fear of injury to the walls, thus adding additional beauty.

You will note that the basis of this desirable result is the concrete wall, possessing as it does, the vital characteristics of stability, texture and color. Possibly one point is open to question, that of color. In most localities the natural color of cement will be sufficiently pleasing; when this is not the case, an increased interest and effect may be obtained by coloring the walls. Whitewash is not costly and, if made from a good formula, will last a considerable time; when weather-worn it can easily be renewed. It is also possible by additions of the earth colors, to obtain the most delicate tints of pink, greys and yellows. Whitewash on wood is cheap and nasty; on cement it is economical and good; its soft, velvety color is pleasing in itself and harmonizes perfectly with trees and shrubbery. Abroad it is held in great esteem.

In concluding my paper I can only add that, to all people who love the beauty of the countryside, the advent of concrete promises much for the future. If, with its aid, our bridges and farm houses are made beautiful, then something well worth while will have been accomplished. It is for you manufacturers and users of cement to advocate the use of cement, not alone for the economical and practical advantages, but also for its artistic value as a building material in the country, and if you can persuade your road engineers to adopt the arch form for bridge construction, and the farmer to use concrete for his buildings, you will have done a good work, for in addition to the practical, useful results achieved by the use of cement, you will also have added a note of beauty to our landscape, a thing devoutly to be wished for by all lovers of nature.

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WATERPROOFING CONCRETE.

BY R. A. PLUMB.

There is a tendency for many of us to live on from day to day entirely unconscious that we are living in a world of wonderful changes. We are truly living in Nature's great laboratory, where physical and chemical changes are incessantly taking place and continually transforming our world.

Foremost among Nature's agencies is water, and we have but to look around us to realize its activity, both as a constructive and destructive element of Nature. The waves lashing our shores and continually changing our coast lines, the glaciers with their heavy mass planing the rocks on which they rest, or our rivers, which are continually eroding their shores and changing their channels—are but suggestive of the different forms in which water is manifesting its activity.

The quantity of water resting on the earth's mass is estimated at thirteen hundred quadrillion tons, which would be equivalent to a universal ocean with a depth of nearly two miles if the surface of the earth were a perfect spheroid. The great part of all animal bodies and of all plant life is water. It is not only a large composite part of all Nature, but it continues to maintain life by supplying food, as the blood in the higher animals and as the sap in the trees. A living world without water would be impossible, as our earth would be nothing more in its activity than a metallic crust with no ability to give birth to organic life. We can truly agree with Pindar, who, back in the early days of Hellenic civilization, exclaimed: "Water is the chief of all."

Realizing the destructive influence of water we should, as concrete workers, be keenly interested in the methods and means of rendering our structures immune to its degenerating effects. Building materials in general, especially concrete, are decidedly porous and absorbent. Water is drawn into foundations from the surrounding soil, and due to the capillary nature of constructive materials, it ascends gradually and finally permeates the entire structure, producing damp, clammy walls which constantly foster and spread disease. It is apparent, therefore, that proper waterproofing not only prevents the gradual decay and disintegration of structural materials, but goes further to establish more hygienic conditions for the benefit of humanity in general. We are all willing to grant that if we can add permeability to the strength, durability and fire-resisting properties of concrete, we have at last produced a perfect building material.

Due to the fact that the subject of waterproofing is at the present time in somewhat of a confused condition, and practically every manufacturer of a waterproofing product is zealously pushing his materials as the "only perfect waterproofing," and the consumer has no general literature on the subject otherwise than what is supplied by the manufacturer, I will endeavor in the following to outline and classify the different waterproofing materials and indicate their specific application to different waterproofing conditions.

In recognition of the distinct differences between damp-proofing and waterproofing in its literal interpretation, it is advisable to consider these subjects as two separate divisions of the general subject of protecting structures against the disintegrating action of water. Damp-proofing should be confined to the consideration of the methods and processes of keeping water and dampness out of the superstructures of buildings, while waterproofing should deal particularly with methods of treating and insulating substructural work subject to hydrostatic pressure, and also to those types of construction designed for retaining water. Damp-proofing products have absolutely no application to waterproofing conditions, and manufacturers of strictly damp-proofing products, who are pushing their materials for waterproofing conditions, are only bringing discredit and encouraging scepticism on the whole subject of waterproofing.

The almost innumerable number of materials on the market for damp-proofing purposes may be simply included in three distinct classes, viz.:

(1) Transparent Coatings.

(2) Opaque Cement Coatings.

(3) Special Bituminous Coatings.

Transparent Coatings.—In this class should correctly be included the products and processes, the application of which does not change the original physical appearance of the surface treated.

The old Sylvester process, although now practically obsolete, should be given some mention as an original effort in this line of damp-proofing. This process involves alternate treatments of the surface with solutions of soap and alum, and depends for its efficiency upon the formation of a greater or less amount of the aluminum salts of the fatty acid contained in the soap, which possesses physically, a very distinct but temporary, water repellent action. This is not economical, as it is necessary to repeat the operations a number of times to produce sufficient insoluble soap to show any efficient repellent action.

The treatment of the porous surface by means of hot paraffine should also be included in this class. This is the process that was used for treating the Obelisk, which was brought over from Egypt and set up in Central Park, and which soon began to show very evident signs of disintegration when subjected to our climatic conditions. In this process the exposed surfaces are first very carefully heated by means of artificial heat and coated with melted paraffine applied with a brush. By this means the paraffine penetrates to a considerable depth before it chills and leaves the paraffine deposited in the pores. Comparatively successful results can be obtained by this method, yet the expense makes its use quite prohibitory in the majority of cases.

Most interesting of this class are the great number of transparent liquid coatings that are applied to the surface with a brush like paint. These products appeared on the market very shortly after the absorbent nature of a concrete block was recognized and were offered as infallible remedies for this detrimental feature of concrete. It is very unfortunate that a greater number of the manufacturers did not deem it necessary to test their materials to determine their efficiency, but chose rather to advertise them broadcast, as perfect waterproofings and reap the benefit of the early business in this line. Analyses made in the writer's laboratory have shown that in the greater number of cases, these products contained nothing more than a low melting point paraffine or wax, fluxed back in a light volatile oil, and depending for their efficiency upon the deposition of the wax or paraffine in the pores of the concrete. We have found so-called waterproofings that contained within themselves over 95 per cent. of volatile constituents that acted purely as temporary solvents and carriers of the very small amount of solid base. It is quite unfortunate that the word waterproofing has been associated with these products, as it has naturally resulted in establishing doubt and scepticism on the entire subject.

The theory involved in these products is entirely correct, viz., the deposition in the pores of the concrete of a permanent water repellent base which will overcome the characteristic positive absorbent nature of the material and impart a negative repellent nature. The trouble has been that insufficient investigation has been given to the character of the material to be used for such a product, and it is only within the last year or two that a very limited few progressive manufacturers have given the necessary technical and careful scientific investigation to the subject and have been able to produce by synthetic means, water repellent bases which show the maximum solution in volatile vehicles, and in two-coat work, do overcome the detrimental nature of porous surfaces. It is therefore encouraging to note that this small, but yet important part of damp-proofing, is being solved and satisfactory products are available.

There is a very distinct field for such coatings as they are the only products which we have for treating the exterior surfaces of porous stone, to preserve them from decay, due to the absorption of water and other atmospheric impurities which result, not only in the unsightly staining of the sensitive stone, but a general surface disintegration due to the disruptive force manifest by the expansion of the water in the pores on freezing.

Opaque Cement Coatings.—Nearly every cement user has practiced coating his cement work with a plain cement grout, and has experienced the difficulty of obtaining a perfect bond and also has observed the tendency of the coating to absorb water. A few of the progressive manufacturers, who have made a special study of the exact requirements of a concrete surface, have produced coatings which are made up from a Portland cement base and which show a perfect bond on the surface coated and are perfectly repellent and damp-proof. These products contain no oil and possess none of the characteristic qualities of oil paints. It is well known that an oil paint has no application to a concrete surface, as the vegetable oils used, react with the alkali in the cement, forming a soap and resulting in the disintegration of the coating. Oil paints also dry with a distinct gloss, which is very objectionable on a concrete surface where the coating should retain the integrity and characteristic texture of the surface coated.

The cement coating have a very general application for uniforming cement surfaces, such as stucco, cement blocks, etc., and replace the somewhat cheerless and unattractive surfaces with a soft-toned surface which is thoroughly damp-proof.

Special Bitumens.—The special bitumens differ from the products of the preceding classes in that they are not applied to the exposed surface, but to the interior of the exposed wall. Such products are black in appearance and are made up from the various selected waterproof gums. They are applied to the interior of a wall with a brush, and besides providing a continuous membrane in the wall which will act as an insulator against the ingress of water, they provide a solid bond for a coat of plaster applied directly on the coating. There are a great number of black paints on the market which are recommended for this purpose but which have shown very unsatisfactory results, in that they do not possess the durability, the elasticity and "tackiness" which are necessary essentials of such a material.

These products very obviously serve an economical purpose in eliminating the necessity of furring and lathing. By this construction the cubic area of available space is increased, and all the disagreeable features of the air space are eliminated. Although the film is a fairly good non-conductor, it has not the same insulating efficiency as an air space, and is not recommended where the results would be unsatisfactory due to serious condensation on the inner surface.

It is the present day engineering practice to waterproof substructural masonry or structures designed to retain water by one of the two following methods, viz.:

(1) "Integral," or rigid method.

(2) "Membrane," or bituminous shield method.

Both of these processes have very distinct characteristic features and should receive very careful individual consideration.

According to the "Integral" method, a waterproofing compound is incorporated in the concrete mass, rendering same waterproof within itself. By the "Membrane" system, the concrete work is insulated from contact with the water by interposing a continuous, waterproof, bituminous shield.

Preliminary to a brief discussion of the merits of these two methods, it is well to indicate briefly, why concrete requires waterproofing. The penetration of water into concrete is permitted by the existence of minute, capillary pores throughout the mass. That such porous structure cannot be avoided, arises from the elementary nature of concrete itself. In the composition of concrete, water fulfills two distinct functions. It is required chemically, for the processes of solution and crystallization, and physically to act as a medium both for depositing and densifying the concrete. The cement not being able to assimilate all the water, the excess is removed by evaporation, and, as the water is incompressible, its removal would naturally leave an unoccupied volume of characteristic porous structure.

The "Integral" method, as stated above, involves the addition of a compound to the composition of the concrete as it is placed, and thus becomes a unit or integral part of the mass. The greater number of waterproofing compounds can be most simply divided into two classes, characterized by the physical condition in which they are added to the concrete, viz.:

(1) The finely powdered dry compounds that are added to the dry cement.

(2) The compounds, either in liquid or paste form, that are added directly to the water that is used to temper the dry mixture of cement and aggregate.

The compounds of the first class are usually homogeneously mixed with dry cement, in the proportions of two per cent. These compounds are chemically, hydrated lime with a greater or less amount of the lime salts of fatty acids. These lime soaps were, undoubtedly, originally chosen as waterproofing compounds, due to their characteristic water repellent property. A careful study of the subject of "Integral" waterproofings will emphasize that the very first essential for successful results, lies in obtaining an even, homogeneous distribution of the waterproofing compound. It is a chemical axiom that in any process endeavoring to produce a perfect mixture, it is fundamentally essential that the body to be distributed must be of such a nature that it will be readily mixable with the distributing medium. On the basis of this fact, it is quite evident that the repellent properties possessed by these dry compounds, are a considerable disadvantage in obtaining an even distribution. It makes very little difference how careful an original effort be made to dry mix a repellant compound with the dry cement and then with the dampened sand; as soon as the water is added the repellent property of the compound will manifest itself, and as the fluidity of the concrete increases, the resistance to flow throughout the mass will decrease and there will be a tendency for the repellent compound to expel itself from portions of the mass and be concentrated in other sections, thereby making an even, homogeneous deposition impossible. Although the repellent feature is an excellent property for a compound to possess when in place in the mass of concrete, its very nature makes the even distribution difficult and thereby defeats its intended purpose.

In the case of compounds that are added directly to the water, there is no difficulty in obtaining an even distribution as they have had the advantages of the water as a vehicle or carrier to evenly distribute them. As far as the homogeneous deposition is concerned, it should be quite evident that the compounds of the second class that are originally mixable with water, have a decided advantage over the dry compounds of a repellent nature. An acceptable compound for this class of work should also contain no organic constituents or other materials that will in any way interfere with the strength of the concrete, as it should not be necessary to sacrifice strength to obtain waterproofing efficiency. A recent report of one of our Universities, gave results which indicated a loss of over fifty per cent. in the strength of the concrete, due entirely to the presence of the emulsified oils contained in the compound.

The "Integral" method of waterproofing has a very general application to waterproofing conditions. It is only limited in particular cases where there is a liability for the continual development of cracks in the work, which would, of course, destroy the waterproofing efficiency. The "Integral" method is very universally employed for substructural work of various natures and to cisterns, reservoirs, etc., which are designed for containing water. The waterproofing compounds can be used throughout the mass of the concrete, or in cases where this procedure would be impractical, due to the cost of the waterproofing, it can be concentrated in a plaster coat on the surface of the structure. Rather than discussing fully the essentials necessary to be considered in applying the "Integral" method, I have briefly outlined in the following a typical specification showing the application of the "Integral" method of waterproofing in the form of a waterproof coat, as it should be used to correct the percolation of water into the basement of a completed building. I have chosen this specification as it emphasizes particularly the application of the "Integral" method of remedying leaky conditions in substructures already erected, where re-excavation would be entirely too costly and in some cases impossible. The specification follows:

1. Intent.—It is the intent of these specifications to correct dampness due to percolation of water through walls and floors in basements in buildings not properly waterproofed during construction.

2. Method of Procedure.—Water-tightness shall be secured by plastering the inner surface of damp walls and floors with an unbroken, continuous coat of cement mortar to which .... as manufactured by ...., has been added.

3. Preparation of the Coating.—The waterproofed cement mortar shall be prepared by thoroughly tempering, to required consistency a dry mixture of one (1) part of cement to two (2) parts of sand with water to which .... has been added in the proportion directed by the manufacturer. The sand shall be clean and spherical and well graded from coarse to fine.

4. Preparing the Surface to be Coated.—Before plastering cement mortar on old concrete, the surface of same shall be treated as indicated in the following:

(a) The old surface shall be cleaned very thoroughly with a heavy wire broom so as to remove all dust and dirt. A jet of steam shall be employed to clean the wall, if available.

(b) To the mechanically cleaned surface, apply with a large brush a liberal coat of 1 : 10 solution of hydrochloric acid. Allow the acid to remain until it has exhausted itself, which will require at least ten minutes. A second liberal coat of acid solution shall be applied before removing the first. A third coat shall be applied if the two applications have not satisfactorily exposed the aggregate and entirely removed the skin of hardened cement.

(c) With a hose under good pressure, slush the surface in one direction so as to remove the salts resulting from the action of the acid. Continue the slushing until the salts and all loose particles are removed and the old concrete is thoroughly soaked to its full hygrometric capacity.

(d) To the cleaned and saturated surface, apply with a strong fibre brush a coating of pure cement, mixed to the constituency of thick cream, with water to which .... has been added in the proportion directed by the manufacturer. Rub in vigorously so as to fill all the crevices and cavities produced by the action of the acid.

5. Application of Coating of Walls.—Immediately after applying the above slush coat, the first coating of waterproof cement mortar shall be applied (thickness $\frac{3}{8}$ inch) directly upon the slush coating and well trowelled into every void or crevice of the surface. Before this first coat has reached its final set a second and final coat shall be applied to an equal thickness, so as to make the full average thickness three-quarters of an inch. The finish coat shall be floated to an even surface and subsequently trowelled free from any porous imperfections. If the conditions of the work make it impracticable to apply finishing coat before scratch coat has set, the latter must be dampened and slush coated before finishing coat is applied.

6. Basement Floors.—The floors shall be treated and prepared exactly as indicated above and finished with the waterproofed mortar to a thickness of two (2) inches. Special care shall be exercised to bond the wall coating to the floor coating, so as to make the waterproof coat absolutely continuous.

The "Membrane" system of waterproofing differs distinctly from the "Integral" in that it does not attempt to treat the concrete but rather to insulate it from contact with water by enveloping the structure in a continuous bituminous shield. The fact that the Membrane is not a unit or rigid part of the structure permits a certain freedom of movement and action in the structure, without impairing the efficiency of the waterproofing. This feature of the "Membrane" system makes it most suitable for waterproofing work not fully reinforced and liable to settlement or subject to vibration or shock such as railway bridges, culverts, etc.,

It was early practice to simply coat the surface to be waterproofed with hot tar or asphalt, but it was soon evident that this was not sufficient as the coating would crack with any movement in the wall. It was therefore necessary to employ some material in addition to the bitumens to contribute the necessary toughness and tensile strength. Burlap and coal tar felts have been extensively used for this purpose and some very satisfactory waterproofing operations have been carried on with such materials. For the last few years considerably more attention has been given to the nature of the waterproofing felts, and as a result there are now on the market specially manufactured felts which are both saturated and coated with bitumen and possess greater pliability and strength. By means of these felts more perfect membranes can be constructed as the strength and toughness of the felt permits greater distortion and twisting to accommodate it to the design of the work.

The bitumens most generally used for cementing the felt together in constructing the membrane are coal tar pitch, commercial asphalts and special asphalt compositions. Although coal tar pitch on account of its cheapness, has been and is still being very extensively employed for waterproofing there is considerable controversy among engineers regarding the relative value of the coal tar pitch as supplied to-day by the more modern methods of gas production and the older process in vogue when pitch was first used for waterproofing.

The asphalts are more suitable for waterproofing as they possess greater elasticity and permanence. In selecting an asphalt for waterproofing purposes special care should be taken to obtain a material of as low a melting point as the nature of the work will permit as it not only insures greater elasticity when subjected to cool temperatures but works much more freely and easily in applying. The special asphalts are usually manufactured from a hard hydrocarbon such as gilsonite tempered with petroleum residuums to impart the necessary elasticity. The residuums used in the prepartion of these special asphalts should preferably be strictly asphalt bases and contain the minimum percentage of paraffine which being of a lubricating nature impaires the necessary binding properties of the asphalt.

The application of a bituminous membrane to any structure should have the same careful attention as any other important point of engineering design. Every job has its particular requirements which should be carefully interpreted and the design fully suited to meet the individual conditions.

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THE USE OF CEMENT IN ARCHITECTURE.

BY F. S. BAKER, F.R.I.B.A.
President, Royal Architectural Institute of Canada.

It is very gratifying to know that no matter how enormous the quantity of Portland cement required in the operations incidental to the development of this vast country of ours, the raw material is available to insure the use of the Canadian product and protect us against the necessity of importing foreign material.

I think that so delicate a material as Portland cement should be shipped in better packages than jute sacks, and claiming an architect's prerogative, I would ask your consideration of the possibility of improvement in this direction.

There is a source of considerable anxiety and annoyance to the architects which I think your chemical experts might overcome with great benefit to every one concerned. I refer to that ingredient in Portland cement (and all seem to be alike in this respect) which so badly stains any limestone or sandstone with which it comes in contact.

Owing to the kindness of the management of the International Cement Company, at Hull, Que., I was given an opportunity, with several other architects, to visit their works and see the whole process of manufacture from the quarry from which the shale was mined to the jute sacks already referred to.

Part of the process was, of course, this crushed shale and clay in the large cylinders at a very high temperature, and it occurred to me then that the qualities which cause the staining of the stone might be some form of carbon which might be eliminated by a further burning or by some chemical process which would not injure the usefulness of the product. Of course we use various methods of overcoming this staining, such as painting the back of the stone and using some non-staining cement in making the mortar used next the stones, etc., but even with these precautions the stains sometimes get through. I have in my mind a very fine public building now being erected of Bedford stone and large areas of the external walls of the building are ruined by this staining.

The subject of concrete will be well covered by various speakers at this meeting, but there is one feature which occurs to me: I refer to the injury which concrete in course of setting receives from any sudden jar. To obviate this where concrete is used for floors in steel frame buildings, I think the architect should provide additional steel sufficient to insure a stiffness in the frames which would prevent injury to the concrete by the vibration incidental to the erection of any steel frame building. I have observed that concrete placed in moderate freezing weather, say twenty degrees and above, which is allowed to set fully without any vibration, seems to be as good as that set in non-freezing weather.

Portland cement has proved very useful in forming surfaces to resist water or tanks to contain fluid, such as cisterns, swimming baths, egg tanks, etc., but the success of this depends largely on the mixture. In a case like egg tanks it is exceedingly important that the walls should be absolutely tight as the slightest subsidence of the fluid causes the eggs at the bottom of the tank to be crushed.

For this reason concrete seems to be the ideal thing for floors which lie upon the earth, such as basement floors, or verandah floors or sidewalks. As a finished floor for a building, however, I do not think a cement and sand or marble dust composition is satisfactory, and the same applies to staircases. I refer, of course, to places where there is heavy traffic, as the floors or treads at once begin to wear, and the consequent deposit is carried into adjoining rooms.

Portland cement shows its greatest usefulness to the architect in the mortar which is now almost universally used in the laying up of brick walls: I mean cement mortar, one to three. A brick wall laid in such mortar and grouted with liquid cement grout every few courses becomes as hard as solid stone, and as compared with concrete the builder has the assurance of strength from his knowledge of the soundness of the bricks and of their resistence to crushing. I have watched men cutting an opening through such a brick wall, and the hard bricks generally yield before the mortar. Such masonry is a great comfort to the architect. In it there is no danger of a weak spot, such as might occur in a concrete wall through the carelessness of the workmen. No matter what precautions he takes, the architect of a reinforced concrete building must have some anxiety on this score until the building has been thoroughly tested, and while I say this I am a great admirer of the wonderful feats which have been performed in the erection of immense reinforced concrete structures and I am satisfied that it is a practical building process. The use of cement mortar in the building of rubble stone walls is also a great boon to the architect; no rubble stonework should be attempted in anything but cement mortar where cement is obtainable. The failures which I have seen in rubble stonework would in every case have been avoided if cement mortar had been used.

While the concrete block is a desirable article for a certain class of building, I have not yet seen any which could be satisfactorily used in a building which was to stand as an architectural effort in a conspicuous place. In saying this I do not include so-called artificial stone, which is a very admirable building material and thanks to the cement in its construction, is now obtainable of the highest quality, in any quantity. And you get it without delay. In this material anything which the architect can design of a masonry character, can be rapidly constructed and reproduced to an endless number. He is hypercritical who condemns this material because it is an imitation. I contend that it is a sound building material, which can be quite properly used where it is obviously artificial stone.

Of the several kinds of artificial stone I prefer that which is formed of the same material all through and not formed in the main of one kind of concrete and faced with another. There is apt to be a difference in the expansion and contraction of two materials and a difference in the retention of moisture, which might reduce the strength of the latter article, as compared with that which is formed of the same material all through. It is clear, however, that an architect must not be drawn into the repetition of a feature so easily obtained in artificial stone in an effort to economize. On the whole, I like artificial stone very much and wish it every success.

A delightful material for use on the interior wall surfaces of buildings has developed recently in plaster formed of white cement mixed with ground stones of different colors.

Of these the most used is perhaps what is known as Caen stone cement. This is now used to finish the interior of the public parts of hotels, hospitals, theatres, banks, stores and even churches. It is applied much as plaster would be and is laid off in courses joined horizontally and vertically, just as real stonework would be. The result is almost a perfect imitation of real Caen stonework, and is, as I said before, a delightful interior finish. On account of its plastic nature the most difficult ornamental work can easily be produced, cast from a carved model, which, of course, can be reproduced as often as desired. The color obtained is splendid, and while it is undoubtedly an imitation and more to be condemned on that score than artificial stone, an architect obtains in its use a most satisfactory result for his client. All the large cities in Canada, and I think I may safely say all the large cities in the United States, have prominent examples of the use of this material for interior finish. In most of these cases all of the interior trim, including the mouldings and ornament, are also formed in the Caen stone cement.

The use of cement has also made possible many embellishments for the exterior of the building, which could otherwise only be obtained at great expense. A whole wall surface may now be safely covered with cement plaster, either on masonry work or metal lath, and the craftsman feels assured that it will stay in position, while at the same time it may be enriched with sgrafito ornament by the skilful carver. On the other hand, friezes protected by roofs or other protections can be modelled in relief on the building, quite as successfully (and at much less expense) as a frieze carved in stone.

I cannot stop without urging upon this Association of influential men, the desirability of doing everything possible to encourage good architecture throughout the Dominion of Canada. You have done in the manufacture of Portland cement more than any other body of men has done in what makes for sound construction in building, and if you will, as a body, take a firm stand in favor of the employment by the public of architects known to be skilled in their profession, you will be able to do much to improve Canadian architecture.

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WHAT CONCRETE MEANS TO THE FARMER.

BY PERCY H. WILSON.

At first thought, the use of cement on the farm would perhaps seem a small thing to the uninterested. Many say, why, yes, farmers will naturally use some cement, a few barrels a year perhaps. But when we realize that in Canada there are about one million farms, the use of five barrels of cement a year on each farm means more than doubling the consumption in a single year. Cement manufacturers and users naturally both look first to the large contracts for supplying them with work, and when such large contracts are for some reason withheld they find one source of their livelihood lost. In 1907 the cement industry in the States reached its zenith, apparently. In 1908 and 1909 general business depression prevented many railroads and municipalities as well as smaller private corporations from doing any new work, while building permits were about cut in half. It was naturally thought that the use of cement would decrease. Yet in 1908 about two million barrels more were sold than in 1907, and while the figures for 1909 are not yet known, it has been estimated that about ten million more barrels were sold.

The only way of accounting for this increase is by the use by the individual in a small way.

And the comparatively small user of to-day is the man to whom we must look for the most substantial increase in the consumption of cement.

The importance, therefore, of having the small user know how to properly and economically handle this wonderful building material is apparent, and in accomplishing that result the work of an association of this kind is invaluable.

In glancing over the history of the use of cement and concrete, we must concede to our brethren across the water the claim for the original use of Portland cement, most of the original systems of reinforcing, and theories on the chemistry of the material which far surpass anything done on this side. But while their theory and design have advanced further than ours, we Americans have been going ahead building in concrete, and in varieties of use and schemes of economic handling we have beaten the world. We have designed and successfully built everything known in concrete, from a dry-dock, in which over 100,000 cubic yards of cement was used, to a concrete hen's nest, for which 1/27 of a cubic yard of cement was required.

Now concrete requires ingenuity in handling, and in this line, the handy man, jack of all trades, finds his use.

The farmer must of necessity be a jack-of-all-trades. He is far removed from the ordinary conveniences of cities, where each piece of work is done by men specially trained for it. He falls and cuts his head. He has to plaster it up himself. Therefore he is a doctor. He kills and prepares for market his hogs and cattle. Therefore he is a butcher. He shoots a skunk in his chicken yard. Therefore he is a hunter. His farm wagon breaks down, and he finally becomes not only a blacksmith but a carpenter. And finally, the good wife goes into town for spring shopping, and preparing his own meals he becomes the cook.

No class of man is probably quite as ingenious, and the advent of cement and concrete has given this man another direction in which to display it. As a result, we find to-day, more small, ingenious uses for cement on the farm than in any other single place.

During the past years, while city, state and national governments were learning the uses and value of concrete, the farmer stood silently by, looking and listening. This man took the ideas home to the farm and began adopting concrete in the country. He knew that many a farm has its own gravel pit and sand bank, or is near a stone quarry. The farm labor can do the mixing and placing, and any farmer is enough of a carpenter to build forms. This leaves him only a few bags of cement to buy, a small part of the resulting volume of concrete and of the cost.

A farmer saw that a concrete walk had many advantages over the board or brick kind. It would be more easily scrubbed, and would have no cracks through which the grass might grow. It would never rot out. But he added an idea of his own, he put a little curb next to the flower bed to keep the rain from washing the dirt over the walk.

A little more thinking and he expanded the concrete walk into a cellar floor. This gave satisfaction, and was so clean that he put another in that most immaculate place of all places, the milk house or dairy. He found in addition to its natural cleanliness, that the milk kept better. An iron grillage in the bottom of the tank allowed the cooling water to circulate under the cans as well as around them. A pipe rail at the back of the tank steadied him while he was lifting out heavy cans.

His next thought was a cow-barn floor, suggested on account of its cleanliness, but he was just a little afraid he was waxing too enthusiastic over the new material. Such a floor might stiffen up his cows and horses. At any rate, he concluded, since it keeps the water out of the cellar, it will keep it in the cistern, and a concrete cistern was next in order. He found the cistern a comparatively simple matter, after digging a hole, and placing inside forms. The top, however, proved slightly more difficult. He found that the top might be cast separately, and afterwards placed over the hole.

But later he found that by a simple scheme of forms he could build the cistern cover in place, and where the old cistern cover was of wood in good condition, or stone, he simply replaced the splintered rotten top with a concrete cover, the man-hole being too heavy for any inquisitive boy to remove.

Perhaps it was the lazy farmer who hated digging, who first built an elevated cistern, running his down spouts into it, and in turn pipes the water from it into the house for direct use. At any rate his wife appreciated his thoughtfulness, for water was always at hand, without the necessity of her having to pump and carry it.

The same idea has been carried into the use of water for stock, by means of an elevated or a pressure tank, fed by windmill or hydraulic ram, the water being drawn by gravity to the desired troughs. With each trough provided with a float cut-off, the tanks in distant fields may always be kept full without overflowing and the consequent waste of water.

Sanitary conditions on the farm are of prime importance, and are being now given the attention they deserve. Having cared for his water supply, he now turns his attention to the spring, from which he may draw his drinking water or from which his stock may water. The stock kick surrounding dirt into the spring, and keep the water muddied. A basin of concrete for the spring itself, with either a concrete or stone apron surrounding it was installed. This kept the water so clear and pure that the deep well for drinking purposes was installed, and protection for this from surface water in the shape of a concrete curb was built.

Of course corn used to be so cheap that many farmers considered unimportant the amount wasted in a muddy feed plot. If the mud became too deep, they fed around over the pasture, changing the spots as the grass wore out. Somebody had advanced the theory that such feeding was good for the soil. But with the higher cost of corn and beef the study of economic feeding as well as the perfect preservation of the manure became of importance. At first feeding floors of wood were built. It was found that they were profitable and food saved, in the general health of the animal, and in a shortened time for fattening. But the two great drawbacks to wooden floors were the rats which infested them, and the constant need of repairs. In concrete he saw the possibilities of an ideal floor, an easily cleaned, rat-proof, germ-proof surface from which his hogs, sheep, cattle and poultry might eat every particle of grain to the last fragment. He laid this feeding floor, and the dirty, unhealthy barnyard passed forever. And in the resultant cleaner condition of stock he saved in the expense of labor as well as obtained a better price for them when sold. At the edge of the floor he built a shallow manure pit or cistern of concrete from which were collected all the washings and waste from the floor. He landed from this to that part of the cultivated fields needing manure most.

To-day the manure question or, as some prefer to call it, the problem of conservation of soil fertility, is one of the most important considerations of the times. Virgin soil produces immense crops as every farmer knows who has cleared his farm, but the time will come in a few years when the soil will refuse to yield these same crops if each year we continue to take away a part of its strength in the shape of wheat and put nothing back in the shape of fertilizer. A few years ago the Dakotas and Minnesota were heralded as the greatest wheat-growing sections of the world, yet to-day the Canadian farmers are growing more bushels of wheat to the acre than their brethren over the line. And the only way the States mentioned can catch up is to carefully preserve in the best possible condition all manure furnished by that other great industry, cattle raising.

To restore the fields to their former producing power nothing has been found more valuable than manure. Depending on the quality of the article, it sells from 75 cents to $1.50 per wagon load. Leaving out the matter of foods, the strength of manure is dependent directly on the course of fermentation or firing.

The farmer of to-day builds a water-tight cistern or pit in which he stores the manure and thereby keeps it as moist as need be, taking not only the solid parts, but the liquid as well for his fields.

By observation, he has become convinced that concrete floors in his cow-barn or stable will not have any bad effect on his stock. The old floors are becoming foul and rotten. By means of gutters he can easily convey the manure outside the barn to his pit. So he puts a concrete floor in his old barn, at the same time cutting off the lower ends of his stanchions where they have suffered from dry rot, and resting them directly on the finished floor of concrete. The gutters which should be not less than twelve inches wide and deep, must be straight. It is important that the cow stands as near the edge as possible. Therefore, as all cows are not the same size, the length of the stall must be changed in such a way as to force the cow to stand at the back edge. A series of slots, allowing the halter racks to be moved forward or back, thus controlling the length of the stall, are provided and places are furnished of a size to fit any cow.

Divisions between the stalls are matters for the taste of the individual owner, and vary greatly. Some go so far as to have no division between stalls. Others stick to wood stanchions, while ironwork, particularly pipe rails, are very popular. Fortunately, a concrete floor permits of the use of any kind of a division fancied.

At first elaborate feeding troughs were thought an advantage, but a hollow in the floor, from which the stock may be both watered and fed seems to be the simplest way to care for this detail; no doubt the concrete gutter is one of the most important details of the floor. The liquid manure, the best part, is drained to the water-tight pit. One load of manure from a concrete pit is worth twice as much as that ordinarily stored on the ground or in pens. And by the use of the concrete floor, the dairy barn no longer reeks of disagreeable odors. Municipal inspection of these barns is becoming even more insistent on absolute cleanliness as a means of protecting the general health. By building such floors, by confining the manure in pits and by paving the barnyard with a concrete floor, general health of the farm family, both person and stock, is greatly improved. The liquid manure now goes to the fields where it will do good, and not to the nearby wells or streams, where it is bound to do harm. Besides, this paved lot, surrounded by buildings and concrete windwalls forms a fine, sheltered exercise place for the animals in winter. Windwalls were originally built of evergreen trees set close together, or an osage orange hedge. These at best afforded a scant protection to the stock sheltered behind them. No wind filters through a concrete windwall.

Stock at one time or another are sure to be subject to the annoyance of mites, lice, ticks or fleas. A concrete dipping tank with proper slopes for getting the stock in or out are being used.

Ten years ago the feeding of silage was practically unknown. Yet to-day in all dairy districts where the climate provides a severe winter this method is in vogue. A silo is a large tank, in which the green, succulent food is kept green, we may say canned, just as the housewife cans her apples, peaches or tomatoes. Originally they were made of wood, but the rapid decay due to alternate wetting and drying was so great that another material had to be found. As so often happens, concrete replaced wood, and to-day silos of concrete are being built almost exclusively. One of your progressive cement companies have constructed a set of metal forms for silo building, the farmer having to pay only the freight on them to obtain their use. Since building them two years ago they have been continually in use. At least twenty silos have been built with this one set of forms.

To find out just how profitable feeding really was, several farmers installed a good farm scale set once for all in concrete, and over this scale, always in perfect balance, he weighs all the feed used and the fattened stock.

The development of concrete building construction on the farm has developed from the ground upward. Timber rots first where it rests on the ground and requires continuous renewals.

Therefore, here is required the most permanent construction. First, a foundation of the simplest form was built. The basement wall followed. Then the lower story, up to the hay mow was considered, and finally the entire barn, basement, walls, floors, gutters, managers, beams and even the roofing tile and shingles are of concrete. The "stump-sucking" horse cannot acquire that habit in a concrete barn, nor can a concrete stable partition be bitten, filling the horse's gums with splinters. As a matter of fact, one may easily imagine a wise horse sharpening his teeth on a manger of concrete.

The concrete barn approach fills a long-felt want on the farm for entrance to the second story of barns, side walls of concrete, for a reasonable distance, hold the fill forever, while a reinforced concrete slab bridges the space between the fill and the barn proper. This permits light and ventilation in the lower storey of the barn, usually the cow-stable, where the old style fill directly against the barn prevented both. The slab also affords shade for the farm wagon, and in the high end of the fill is a fine location for a root cellar.

Root cellars or, as they are sometimes called, cyclone cellars, are easy and cheap to build, and form a perfect protection for both roots and men. Once built, they are always in repair and always ready to receive anything the farmer desires.

Years ago there was an idea that a hog was a dirty kind of an animal at best, and would thrive better in dirt than out of it. "As dirty as a pig-pen" became a most common phrase. This has been proven an altogether wrong theory, and to-day a hog, if given a fair chance, is as clean as any other animal. I call your attention to a hog house lately built at one of our experimental stations, a concrete "hog palace," as some enthusiastic farmer called it. These houses are warm in winter and cool in summer, items especially valuable to men raising fat hogs. The building is easily cleaned and disinfected, which renders it proof against harboring the germs of hog cholera.

No less serviceable is the concrete hen-house. Mites, bugs and lice cannot hide about concrete. Concrete hen's nests are the most sanitary kind, and I am told are taken to kindly by the hens. To disinfect such a house or nest you may spray it with oil, and burn the oil off, with no bad effect on either. Concrete nest eggs are attractive to the hens and such eggs are hard to break.

For years the artist has been bewailing the passing of the old zig-zag stake and rider rail fence, but it had to give place to the less expensive post and board construction. Boards became too costly and gave way to wire fencing in various forms. Wooden posts in turn are now too expensive for their lasting qualities, and are rapidly being successfully replaced by concrete posts. Such posts do not in first cost exceed that of $1 wooden posts. In the long run they are much cheaper. A wooden post rots out in from five to ten years, concrete posts last forever. They possess another advantage, on account of their uniform size, similarity in looks, and clean, trim appearance, they give the farm the neat finish once popular in the old white-washed fence. They are not difficult to mould. The farmer may make wooden moulds or buy the neater style of steel. On rainy days and at odd times a sufficient number of posts may be moulded for demands, and laid away to season. Unlike the wooden variety, the older they become the better they are. Ornamental gate posts at the entrance to cemeteries, parks and private places, thanks to concrete, are adding greatly to the general appearance of the grounds. Clothes poles, stepping stones, and poles for grape vines are commonly used for concrete, and are found to be always ready for use. No annoying renewals are found necessary each spring, when time can be so much better used in other ways.

The mere mention of Europe calls to mind pictures, real or fanciful, of gray old castles, of vine-clad cottages, of firm even roads, and of graceful stone bridges, all very beautiful and, such as exist, mostly relics of the cheap labor of feudal days. What is your opinion of the concrete castles of one of our captains of industry, or of the home-like smaller dwellings, or of the cosiness of the concrete bungalow. To-day concrete houses are being built large or small, plain or fanciful, to fit every taste and every pocketbook.

After putting in a concrete walk the farmer naturally turns his attention to the concrete steps, and after that the porch floor.

The house of concrete comes along most naturally and the farmer is relieved forever from his dread of that terrible scourge—fire. Concrete is fireproof.

If a farm hand is so careless as to drop matches or a lighted lantern on the floor, the concrete barn will not burn up. The hay or feed on a single floor may be destroyed, but the fire may be easily prevented from going through the rest of the building. It is always possible to remove the animals before injury. At worst, only the contents of the barn are destroyed, which is nothing like as disastrous as though the entire building was lost. Insurance companies base their rates very generally on the amount of fire protection afforded and the farmer in the outlying districts gets little such protection, although concrete pressure tanks and cisterns give high enough pressure for water to flow into the house. The high rates paid for insurance on farm buildings is the result. Where buildings are of concrete the farmer can afford to take the risk of no insurance.

About a year ago a terrible fire destroyed a large part of a town in Massachusetts. The fire in one direction was stopped by a concrete house, partially finished. The forms of wood burned off, but after the fire the owner proceeded to complete his house and is living in it to-day. This town was considered to have an adequate fire department, yet the town was destroyed. What chance has a farmer in an extremely remote district to save either house or farm buildings with a fire once well started. What a possibility of loosing some of the dear ones!

No better commendation of the healthfulness of concrete dwellings could be asked for than the recently erected model concrete house for the treatment of tuberculosis patients. Concrete houses are germ and vermin proof. They afford not only perfect health protection, but also, through their concrete chimneys and floors, security from fire. Built once they are built forever, no more painting, no repairing, no rebuilding. Passing from the house lot let us look at what cement has done for the garden or yard. Green-houses and hot-beds are to-day better and cheaper of concrete. The lawn roller is broken. Cast the old barrel in concrete, or cast a new one of the same size, using the old draw rods. Flower pots or flower boxes of cement never rot, and may be made as artistic as the taste of the maker will permit. Concrete garden furniture may be made, while tops of walls or gate posts as well as chimneys, last forever.

A new kind of dentistry is being practiced, in which concrete plays a most important part. This is not the nerve-racking kind we have all experienced but is known as tree dentistry. By carefully cutting out the decayed wood, and filling the tree with concrete, many beautiful old trees have been preserved. The concrete not only prevents further decay, but strengthens the tree as well.

I have only been able to scratch the surface of the numbers of uses which a farmer can and has made of concrete, and I fear were I to continue at much greater length you would all fall asleep. But before closing I wish to call your attention to a growing use, that of grain elevators. A grain elevator is too large for any individual farmer, but by co-operation among the farmers of a community one can be easily built. As has been found in Baltimore, Philadelphia, Minneapolis and many other places, no kind of an elevator keeps the grain as well as one of concrete and it requires no repairs.

To you who are contractors, I would suggest the possibility of much work among the farmers. With a power mixer, moulds on wheels, together with adjustable forms any class of construction may be done desired by the farmer. Sand and gravel from the farm, cement from the nearest dealer, and, Presto! buildings are repaired, health is preserved, the dangers of fire are eliminated, and the farm is given a permanent improvement which certainly adds to its value.

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CONCRETE MUNICIPAL BRIDGES.

BY A. W. CONNOR, B.A., C.E.

The use of concrete for bridge work has increased very rapidly within the last few years. The municipalities have now become interested in concrete, as they see more and more of its successful use in various structures. While the advance has been rapid, there is every reason to believe that the very popular position which this building material has attained will be maintained.

The concrete bridge appears to have come in as a cheap substitute for the masonry arch, but it was soon realized that it had a status and individuality of its own. It has practically supplanted the masonry arch, except occasionally for facing a concrete structure.

It has also proved a very strong competitor with the steel bridge. Each type of bridge has its own place according to local conditions. For short spans the cement bridge is generally cheaper than the steel bridge with concrete floor and substructure. Where good foundations are obtainable, the concrete bridge has been found to compete successfully up to spans of about 100 feet. Cost is, of course, not the only consideration, and many long-span concrete arches have been successfully built, and others and larger ones are contemplated. The results of these large undertakings will be watched with much interest.

The concrete bridge has much to recommend it. It is permanent structure, economical in the first cost and requires no expenditure for maintenance. It is perhaps the only structure that improves with age. On account of its greater weight, there is practically no vibration due to moving loads, and floods are unable to dislodge it. It is also fireproof. In most cases the ordinary roadway is built right across so that one might never notice the bridge in driving over it. This is an advantage in driving cattle over it. Another advantage of the concrete is its superior appearance and its adaptability to architectural treatment. As the concrete bridge is a permanent structure, it seems a mistake to spare the relatively small extra expense in order to improve its appearance, by a little extra care in the surface treatment and by building a concrete railing instead of a cheap gas pipe rail. The reinforcing steel will also outlast the steel in a bridge on account of its being protected from rust, and also being subject to less vibration.

The merits of the concrete bridge above mentioned are of course conditional on proper design and careful and honest handling of the materials. No building material can give good results unless it is properly used. Some failures have resulted from the neglect of one or both of these points.

The simple lines of the concrete bridge have led men to think that anyone can draw a plan of a concrete bridge, and that a little steel buried somewhere in the concrete will give it infinite strength. As a matter of fact the concrete structure requires greater knowledge and experience, and certainly more calculation, than a similar steel bridge. The best, as well as the most economical structure, results from careful design, in which every part of the structure is of equal strength and where all the material is so placed as to have its maximum efficiency. This requires both theoretical and practical knowledge of every detail of the construction by the designer. The cheapest plan is always the most expensive in the long run.

The limits of this paper forbid any attempt to describe the methods of calculation, so only a few words will be said. The bridge must be designed to carry its own or the dead load, and the moving or live load. This latter is usually taken as so much per square foot of the floor or as a concentrated load, such as a road roller or traction engine. The load assumed will depend on the present and possible future traffic. Every possible condition of loading must be considered, and, paradoxical as it may seem, the full load does not cause the greatest stress in parts of the structure. Another stress that has to be figured on, is due to expansion and contraction from temperature changes. The effect of wind and impact has also to be considered, though in the heavy concrete structures these are of less importance. The sum of all the stresses that may result must always be within the safe limit for the steel and the concrete. What those limits should be is not very definite, different engineers differing in their judgment of what will give a sufficient factor of safety. Doubtless further testing and experience will lead the way in this matter, and a specification may be drawn up and generally adopted. Equal attention must be given to the abutments. The thrust must be calculated and the size of the abutment determined so as to make it stable and rigid. The higher the arch is about the foundations, the larger will the footings be. Also, the flatter the arch, the greater will the thrust be, and the larger the abutments. The bulk of the abutments is sometimes reduced by using reinforced buttresses, instead of the solid construction.

Due care in construction is also essential, in order that the assumptions of the designer may be fulfilled. Carelessness still prevails in this regard, as it is often thought that anyone can mix and handle concrete. While it can be handled by unskilled labor, it requires skill and vigilance on the part of the foreman and competent inspector. Every batch must be of properly proportioned materials and well mixed and deposited in place. This cannot be too strongly emphasized.

The bulk of materials required are generally close at hand and local labor is also used in the construction. The principal materials used are cement, sand, stone or gravel, water and steel, and wood for the forms and bracing. The method of construction will be dealt with by another speaker. The cement should be the best Portland cement and it should always be specified that it shall fulfil all the requirements of the Standard Specifications of the Canadian Society of Civil Engineers. The sand and stone or gravel should be properly proportioned and mixed, so that all the voids are filled. If the sizes of these materials are properly graded, the less will be the percentage of voids and the less cement may be used. Usually these proportions are specified by volume, regardless of the material used or without stating whether the cement is measured loose or not. This is a mistake. For larger work careful measurements should be made and tests made to determine the proportions to obtain the strongest concrete. The requirements for the various materials will not be dealt with further in this paper.

There is a good deal of controversy as to the best kind of steel for reinforcing concrete bridges. It may be prefaced that steel is used to take up tensile and shearing stresses and the concrete to take up the compression. The steel and concrete will each take up the other stresses also, but each is cheaper in its own field. This is the raison d'etre for reinforced concrete.

The concrete protects the steel from rust. Into the controversy of the kinds of steel to be used, we cannot go, but merely state the posture and types roughly.

The first division is between high carbon and medium steel. The former has a higher strength and elastic limit, but is more brittle and cannot be so readily fabricated. The medium steel is what is used in steel bridge work, and is less liable to sudden failures. The advocates of high carbon steel, claim that less steel may be used, but it is a question if the higher stresses in the steel with consequently greater stretching and reduction in area of the steel, will not injure this concrete by undermining the hair cracks (and possibly therefore impair its rust-resisting properties), and also have a greater tendency to break the bond of the steel and concrete. It is claimed that this has happened to beams after being in use for some years. The writer considers it best to be conservative and not allow higher unit stresses until time has justified them.

The second division is between the various patented shapes of bars made of either high carbon or medium steel. There are the plain unpatented bars, the corrugated bars and bars with stirrups which are patented.

The purpose of the corrugated bar is to increase the bond of the steel to the concrete. The stirrup, whether a part of the bar or rigidly fastened to it, will also do this and also take up the shearing stresses. That the bond is essential is beyond question, for it is only thereby that the steel can take up its load. This bond must also be continuous, for the increment in tensile strength must come from the horizontal shear in the concrete at all points. That plain bars have sufficient bond, and if bent up at the ends of a beam to take up the maximum shear, are satisfactory according to tests made is also true, but laboratory tests are not entirely conclusive as to the effect of continuous loads and shocks received during a number of years. Steel certainly acts differently under repeated loads. It is felt, therefore, that a corrugated bar offers greater security than a plain bar, and stirrups even greater. The corrugations increase the bond. The bond is reduced by moisture, vibration and reduction of sectional area of steel in tension. The stirrups also take up the shearing stresses throughout. Concrete is not very reliable in shear, and less so if of poor workmanship. Besides the above styles of bar, plain twisted steel bars are largely used. They are, therefore, like a corrugated bar, and though of medium steel have their strength and elastic limit increased by the process of twisting.

The durability of a good surface for appearance is evident. This is usually obtained by careful work in preparing the forms and working the stones away from the surface with a suitable tool. This is better than afterwards plastering the surface. Another method is to use a richer outside mortar, white or colored as desired. This is done by putting it outside of a steel plate near the forms, which is gradually raised up as the work progresses; another scheme is to rock-face or bush-hammer it. Another desirable feature is to use a handsome concrete railing, either separately moulded or moulded in place. The concrete bridge is thus capable of very artistic treatment.

We will now briefly describe the various types of concrete bridges.

(a) Reinforced slabs are largely used for short spans.

(b) Deck girder bridges with slabs over the beams resting on concrete abutments. These are suitable up to about 40 feet span, and are generally cheaper than an arch if the foundations are not good.

(c) Girder bridges similar to the above but with floor near the bottom and carried by two girders which also act as hand rail. This type is suitable where the waterway is limited.

(d) Concrete slab and beams where steel I-beams are used instead of reinforcing steel. This is not strictly a concrete bridge, as the steel beams carry the load and the concrete is only for the protection of the steel.

(e) The arch; this is the most popular type and may be divided into arches with or without hinges. The hinged arch is rare in this country, most examples occurring in Europe. The arch without hinges is the usual type in this country and the arch ring may consist of a single monolithic ring or a number of ribs. The roadway may be carried on fill held in by the spandrel walls, or it may be carried on a concrete slab, or a series of subsidiary arches on top of the main arch ring or arched rib, or on a series of beams and columns.

The spandrel-filled arch is the most common and is suitable for shorter spans, and the slab style for long spans. In cases where the foundation is less reliable, the weight of the structure may be considerably reduced by using a slab or beams and columns, as for longer spans, but with solid spandrel walls.

The shape of the arch may be circular, parabolic or elliptical. The circular arch is the usual type, either segmental or three or five centered. Where the rise is small it may be figured as a parabolic ring which is simpler than the circular ring.

The rise of the arch should be at least one-tenth of the span. The greater the rise the more economical the design.

Provision should be made for expansion. The spandrel walls of arches should have expansion joints or planes of weakness. It is our custom to have the spandrel walls separate from the arch ring, but fastened thereto with dowels. This allows the arch ring to rise and fall with temperature changes. For girder bridges the beams should slide on one of the abutments unless the abutments are free to turn slightly about their footings.

The top surface of a concrete bridge should be waterproofed by plastering with a 1 to 1 mortar before the concrete has set or by coating with pitch or asphalt. Any place where water might lodge should be drained.

[*This Association is not responsible as a body for the opinions expressed in its Papers by Authors.*]

AN ANALYSIS OF CONCRETE BRIDGE FAILURES.

BY C. R. YOUNG.

Since one of the objects of this Association is to discover by conference and discussion the proper and legitimate field for concrete as a material of construction, any facts which might serve to define its limitations or establish the practicability of its use for a given class of work would merit consideration by the body here assembled. For this purpose no more useful or illuminating data are available than the records of failure of concrete structures. The merits or weaknesses of a material are often strikingly disclosed under such extreme conditions, and in most, if not all, cases of failure careful consideration of the evidence will show that not the material employed but some other circumstance is at fault.

The opponents of concrete have in the past hailed every case of failure in concrete construction as an additional demonstration of the entire unsuitability of the material for strong and permanent engineering works, and nowhere had this attitude been more pronounced than among those interested in the manufacture and sale of steel bridges. In some of the townships, and even in some of the counties, where the agents of steel bridge companies have been particularly active and aggressive, confidence in concrete has been materially impaired by the sweeping and grossly misleading statements of these interested parties. The layman is not in a position to disprove such damaging assertions and generally accepts them without question unless more impartial witnesses are forthcoming.

In order to ascertain the ground, if any, on which the representations of the opponents of concrete bridges are based, the writer has looked into the cases of concrete bridge failures of which he could obtain reliable information pointing to the cause of failure. The number of these cases is necessarily small, for, although many failures have taken place in the years that concrete has been in use as a material for bridge construction, it is difficult, for obvious reasons, to obtain information for publication concerning such. However, through the kindness of several engineers, it has been possible to supplement to some extent the data obtainable from published records and personal observation.

although from the nature of the subject the location of all bridges and the names of those who might in any way appear to be responsible are withheld, except in certain cases where such information has already appeared in the technical press. The former cases are therefore designated by number only.

The data thus collected are presented below in as concise a form as possible consistent with a full statement of the circumstances in any way likely to aid in placing the responsibility. Some attention is given to cases of pronounced cracking of spandrel and wing walls, since, such developments, while not incapacitating the bridge for present traffic, constitute failure to the extent of impairing the bridge aesthetically, if not materially shortening its life. From this evidence the cause of failure (complete or partial) is deduced in each case and a summing up of the cases is presented at the close of the paper.

CASE 1.

Reinforced concrete slab or flat-top bridge of 10-foot span intended to carry a fill of thirteen feet above the top of the slab; slab, 12 inches thick reinforced by longitudinal rods $\frac{3}{4}$-inch in diameter, spaced 12 inches centre to centre, and transverse rods of the same size 2 feet centre to centre; spandrel wall, 2 feet thick at the bottom reinforced by vertical $\frac{3}{4}$-inch round rods 2 feet centre to centre.

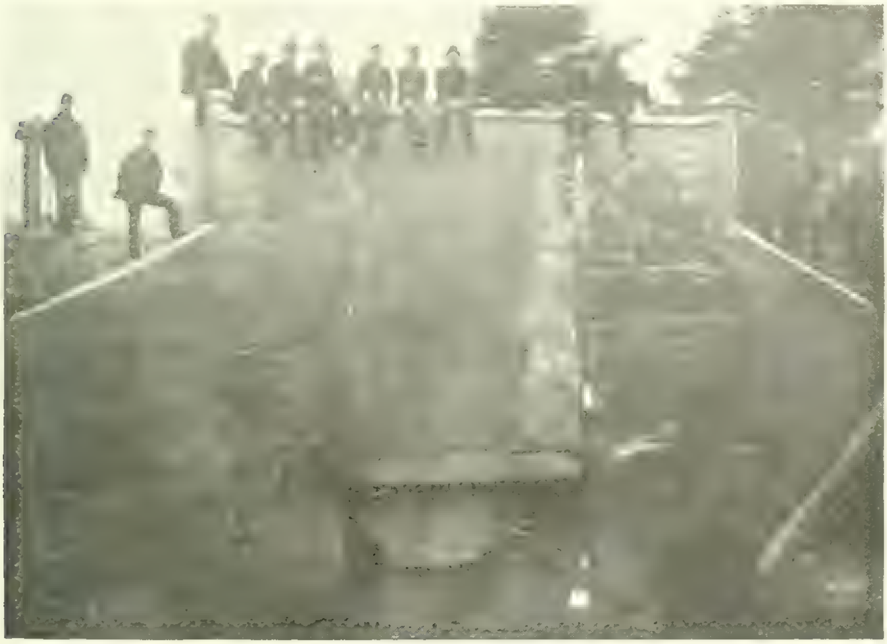

Fig. 1.

After the concreting had been completed nearly two months and some 10 feet of the earth fill had been placed, the centres were struck with the result that almost immediately the slab collapsed under the weight of the fill alone, leaving the spandrel and wing walls intact as shown in Fig. 1.

An examination of the wrecked structure at once directed suspicion to the design rather than to the materials or workmanship. The concrete was apparently of correct proportions, had set satisfactorily, and had evidently been placed with care. Computations based upon measurements of the slab taken after the failure showed a fibre stress of 41,500 pounds per square inch in the steel and 1,100 pounds per square inch in the concrete under a 10-foot fill. Apparently, no special care had been taken to properly anchor the longitudinal reinforcing rods, so that under this stress considerably in excess of their elastic limit, they had pulled through the concrete, as was evidenced by the polished state of the concrete in contact with these rods. The failure can therefore be wholly attributed to a defective design.

CASE 2.

This structure, which is typical of a number of reinforced-concrete girder bridges completed in a county in the State of Indiana some three and a half years ago, was of span 15 feet in the clear and 16 feet clear roadway. Two longitudinal girders, 15 feet 10 inches centre to centre, carrying a 7-inch slab comprised the superstructure. Upon this slab was placed a 12-inch earth fill and in addition it was supposed to carry a uniformly distributed load of 200 pounds per square foot or a 20-ton road roller. The slab was reinforced by transverse rods of a sectional area of 0.78 square inches each, one inch from the bottom and 10 inches centre to centre, and by longitudinal rods ½ inch in diameter and about 3 feet centres.

Before the striking of the centres, Mr. Daniel B. Luten, President of the National Bridge Company, in a communication to Engineering News, pointed out the weakness of the design and questioned its safety. He showed that under dead load alone the compression in the concrete of the slab would be about 1,000 pounds per square inch and the tension in the steel would be nearly 20,000 pounds per square inch, while for the specified live load consisting of a 20-ton roller these figures became 3,000 and 55,000 pounds per square inch respectively.

Before Mr. Luten's letter had appeared in the journal mentioned, startling confirmation of his deductions was given by the collapse of the bridge under a traction engine the day following the removal of the centres. From the testimony of the engineer in charge of the engine, the bridge gave way when the rear wheels were about in the centre of the span, and indications pointed to the slab as the initial source of failure. Careful examination of the wreck disclosed no broken steel and failure was apparently caused by excessive compression in the concrete of the slab.

Under the loading of the traction engine, which weighed about 16,500 pounds, and of which 9,000 pounds were concentrated in the rear axle, this compression could not have been less than 1,800 pounds per square inch with the tension in the steel about 32,500 pounds per square inch. The corresponding stresses in the girders were about 1,000 pounds per square inch for the concrete and 20,000 pounds per square inch for the steel. The compression in the concrete of the slab was therefore nearly equal to the ultimate strength of a good concrete one month old, and in excess of the strength of the material used, which appears to have been of poor quality on account of the presence of "dirt" in the sand. Very bad design and lack of care in preparation of the concrete were, therefore, clearly responsible for the collapse.

Case 3.

Reference has been made to a number of girder bridges similar in design to that of Case 2, constructed during the same year as the latter, in the State of Indiana. One of these of 24-foot span developed a bad crack in one of the beams shortly after the striking of the centres but managed to hang together and carry the traffic for about a year and a half. There was no load on the bridge when it finally fell and no evidence could be discovered of any weakening or undermining action from floods or other causes. It, therefore, appears that its downfall, like that of its companion in disaster, was due to the errors of an inexperienced or careless designer.

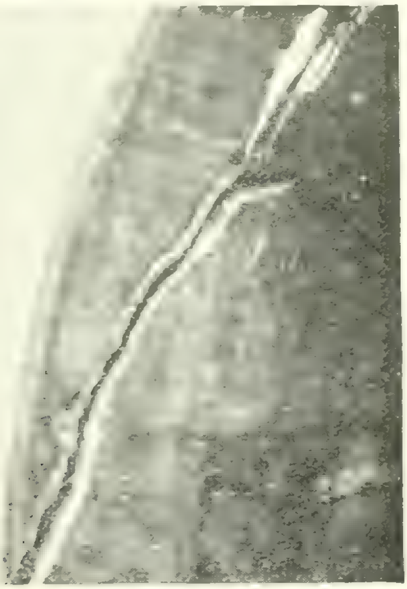

Fig. 2

Case 4.

Plain concrete railroad culvert of 20-foot span and 10-foot rise, carrying a fill of about 10 feet over the crown thickness about 18 inches; foundations were carried 4 or 5 feet below the natural level of the ground. The situation of the bridge was on marshy soil, and the foundation-bed was of soft clay with considerable organic matter present, *but no piles whatever were used.*

As the filling was placed on the arch, cracks began to develop, in the case of the west wall, passing vertically up the wing walls near their junction with the spandrels, then crossing this corner and trending to the crown of the arch, reaching it at about one-quarter of the length of the barrel in from the face of the spandrel walls (Figures 2 and 3). In the east wall a large vertical crack passed from the footing up the soffit to near the crown where it joined a large horizontal crack running along nearly the whole length of the arch barrel. In addition to these very prominent cracks many other tributary cracks of lesser extent developed.

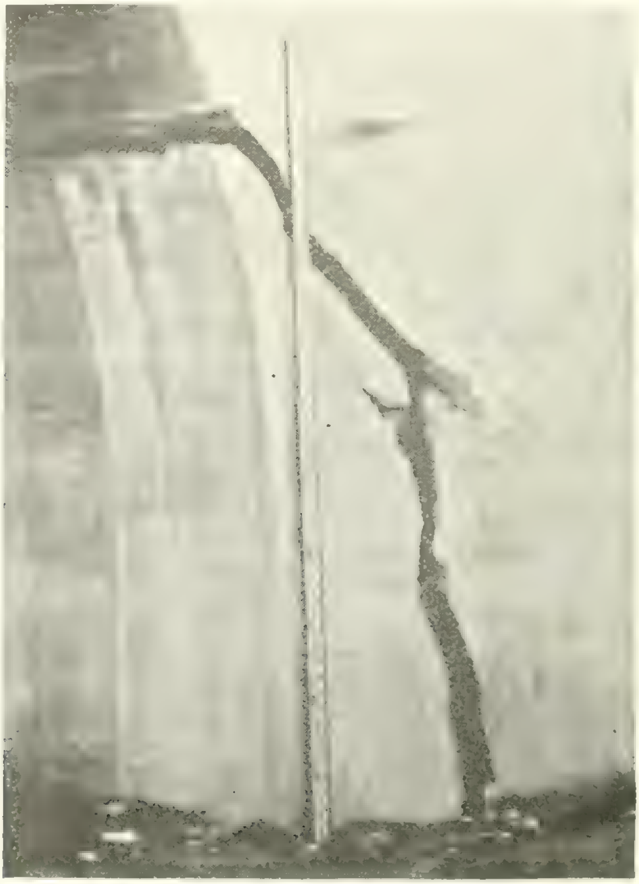

Fig 3.

Careful examination of the cracks in conjunction with the originally level mould board lines conclusively showed that the abutments had settled from 4 to 6 inches under the heavy load of the fill, and that the insecure foundations were wholly responsible for the failure.

The writer is indebted for the above information to Mr. F. L. Somerville, Consulting Engineer, Toronto, under whose observation this failure came, but who was in no way responsible for the design or construction of the bridge.

CASE 5.

A plain concrete railroad culvert 10 feet in span carrying an embankment 52 feet in depth, was constructed in the winter. The foundation-bed was of soft clay and no piles were used. In the following spring, when the frost came out, a portion of the barrel near the middle collapsed under the weight of the fill and a part of one end with one of the wing walls gave way under the sliding of the embankment, as shown in Fig. 4.

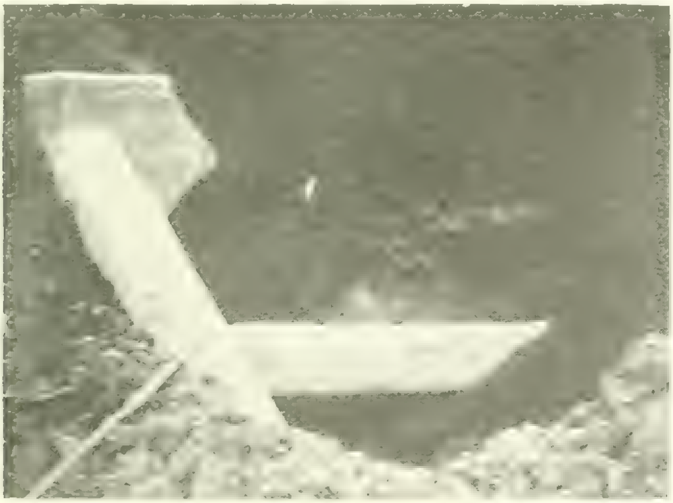

Fig. 4.

The explanation offered for this failure, and one that appears reasonable, was that the spring thaw had destroyed the even bearing of the culvert on the foundation-bed and that the barrel had thus been resolved into a beam at several points, the wrecked end portion acting as a cantilever. Had reinforcement been used, which is particularly desirable in winter work of this class, the structure would no doubt have safely withstood the adjustment.

CASE 6.

A reinforced-concrete arch highway bridge of about 30-foot span and of low rise was constructed with abutments resting directly upon a quicksand bed and in a situation involving the excavation of a new channel for the stream. Shortly after the striking of the centres the arch ring collapsed, although subsequent computation showed the design to be sufficient.

While the early removal of the forms may have been to a small extent responsible for the failure, the excavation for the new channel appears to have immediately precipitated the fall. Under the considerable weight of the arch, and favored by the removal of material between the abutments, lateral flowing of the quicksand with attendant settlement and tilting of the abutments naturally followed. Had the foundation-bed been piled, this development could not have taken place. Faulty design of foundations was, therefore, primarily responsible for the failure; but, unless some of the piles had been driven on a batter, bad cracking of the spandrels would have occurred under the conditions named.

CASE 7.

Some seven years ago a Monier arch of considerable size and built at an extreme skew, collapsed at Bendigo, Australia, with loss of life. The failure was sudden and unattended by any premonitory signs of distress unlike the recorded character of failure of Monier arches, which had been tested to destruction in Europe and elsewhere. In view of the fact that the abutments were especially massive and securely founded on solid rock and that the materials were excellent, the contractor attributed the disaster to incorrectness in the received theory of skew arches and retained the services of the late Professor W. C. Kernot, of the University of Melbourne, to conduct a thorough investigation and report upon the cause of failure.

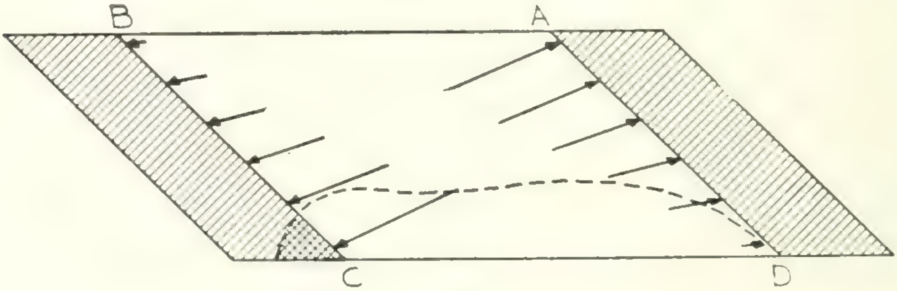

Fig. 5.

By means of measurements of the deformation of loaded India rubber models and by ingenious electrical experiments on a metallic model, corroborated by mathematical calculations, Professor Kernot was able to show that Rankine's theory of the skew arch, which had up to that time been universally accepted, was altogether erroneous. Rankine's view, as stated in his "Applied Mechanics," was that "the forces which act in a vertical layer or rib of a skew arch with its abutments, are the same with those which act in an equally thick vertical layer of a symmetrical arch with its abutments, of the same dimensions and figure, and similarly and equally loaded." It followed from this assumption, therefore, that the design of a skew arch in no way differed from the design of a right arch of the same span as the span of the former measured parallel to the longitudinal axis of the bridge. Professor Kernot, however, conclusively demonstrated that there is a great intensification of stress along the short diagonal AC of a skew arch (as indicated by the arrows in Fig. 5), the actual stress being almost exactly double the stress along lines parallel to AB. At the same time the stress along the long diagonal BD was excessively small.

The existence of such a stress condition is particularly serious since the acute angles of the abutments are of insufficient mass to properly resist the augmented thrust in the direction of the short diagonal, and if the skew be large, the factor of safety low or the test load unusually heavy, the abutments may give way at these points. This is precisely what happened at Bendigo, for the acute angle C of one of the abutments was literally pulverized over the double-hatched portion by the local intensification of the stress, and the part of the arch enclosed by the irregular dotted line and the line CD had consequently fallen.

The cause of this failure lies unquestionably in the lack of knowledge at that time of the true principles of proportioning skew arches and their abutments.

CASE 8.

The most recent concrete bridge failure of magnitude, occured on February 28th, 1910, when a reinforced-concrete arch highway bridge of three spans over the Flat Rock River, near Edinburg, Ind., collapsed during a flood of exceptional height. The bridge had been open to traffic for about eight months, and during that time had stood one severe flood accompanied by an ice jam.

As designed, the structure consisted of one central span of 90 feet and two side spans of 75 feet each, all foundations to be on piles. Although the design was submitted by a well-known and responsible concrete bridge company, the County Commissioners decided with the wisdom born of inexperience, to save money by omitting the piling and carrying the piers and abutments down to a somewhat greater depth than originally contemplated. Beyond furnishing the design, which appears to have been entirely satisfactory with the possible exception of insufficient provision for flood waters, the bridge company had nothing to do with the work, and the County Commissioners for whom the bridge was built had no engineer to advise them or supervise the construction. In spite of this, and to the credit of the contractor, the materials and workmanship were of excellent quality, many of the particles of stone and gravel of the concrete having split instead of being torn out of their place by the collapse.

Upon careful examination of the wreck by a member of the editorial staff of Engineering News, it was found that the scour actuated by a considerable quantity of lodged drift had undermined the upstream end and one side of one pier, causing it to tip forward and endwise, and resulting in the fall of the two arches which it carried. The other pier being thus left without support to counteract the thrust of the remaining arch, likewise tilted, allowing this span to drop vertically into the river. There was no evidence to point to any other cause of failure than undermined foundations, and the responsibility for this rests with those who altered the original plans and specifications.

CASE 9.

The most extensive failure in reinforced-concrete bridge construction of which records are available, is that of the City Bridge across the Illinois River at Peoria, Ill. On May 1, 1909, three spans and the two intermediate piers of a six-span arch structure which had been opened to traffic only a few weeks, collapsed before the supporting centres had been struck. The wrecked spans were each Melan arches 125 feet in the clear, of 13½ feet rise, and of the solid spandrel type. Practically all of the earth filling was in place at the time of the failure. The two ruined piers were specified to be founded upon piles driven to bed rock, though subsequent investigation showed that probably most of the piles stopped at less stable material. In addition, the piles were to be enclosed by permanent water-tight, tongue-and-groove sheet-piling or Wakefield piling to safeguard the pier foundation against scour; but, in spite of repeated warnings on the part of the consulting engineers, this was not done, nor was any protection in the way of riprapping provided by those directly in charge. As a result, during the high water of the spring of 1908, the scour was most serious, in the case of one pier reaching to 3.8 feet below the base of the pier or 11 feet below the original bed of the river.

Since the design and construction of the superstructure was apparently entirely satisfactory, it, was, therefore, not difficult to assign the cause of failure. The lateral support and the frictional resistance of the piles under the two piers in question having been largely removed by the excessive scouring action of the water, buckling and considerable settlement would naturally follow. This action was no doubt largely precipitated by a serious settlement and movement in a shoreward direction of one of the abutments, which began a year prior to the collapse of the structure.

Under such circumstances, there is little doubt that the cause of failure was insecurity of foundations.

CASE 10.

This is not a case of total or even partial collapse, since the bridge in question has been in constant service since its completion some two years ago. It affords, however, an excellent example of spandrel wall cracking, and as such will be used to illustrate a general discussion of this defect, which, as has already been stated, constitutes failure to a limited degree.

This bridge, having a span of 60 feet in the clear, a rise of 6 feet and a crown thickness of 15 inches, developed pronounced cracks in the spandrel walls, as shown in Fig. 6, immediately upon the striking of the centres, although the spandrels are reinforced in the region of the springings by three longitudinal $\frac{3}{4}$-inch round rods. One of these rods is in the coping and the others are located at distances of one and three feet below it. Each of the abutments rests upon a large number of vertical piles driven into quicksand.

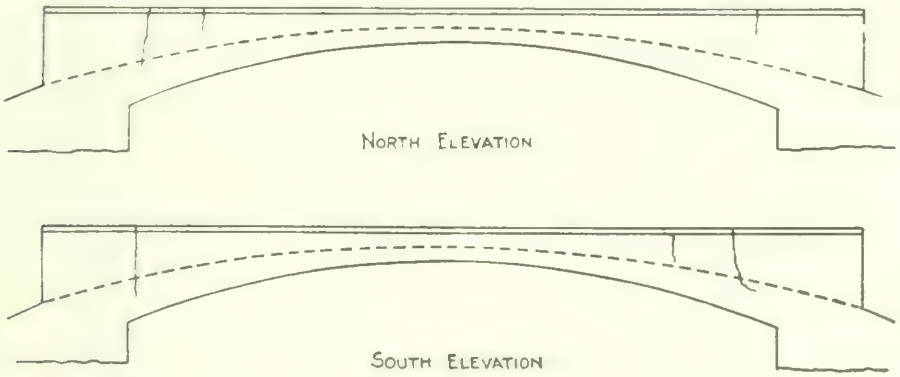

Fig. 6.

The conspicuous character of the cracks is evident from Fig. 7, giving a photographic view of one of them in the southeast spandrel wall. In this case the crack passes well into the ring, although not as far as the one in the southwest spandrel, which reaches practically to the centre of the ring, as shown in Fig. 6.

With the object of explaining the existence of these cracks in spite of the longitudinal reinforcement in the spandrels, the writer obtained information concerning the dimensions of the abutments and constructed the diagrams shown in Fig. 8. In this diagram the various forces acting upon the east abutment are shown in magnitude, direction, sense and point of application for a vertical longitudinal rib or strip, one foot in thickness. The thrust of the arch P_1 is given for the weight of the arch ring and filling only since the spandrel cracking occurred without any live load on the spans. P_2 and P_3 are the weights of the two trapezoidal prisms of filling resting on the abutment; P_4 represents the lateral pressure of the earth filling acting on the vertical projection of the abutment and tending to force it forward into the stream; P_5 is the pressure of the water and the saturated material of the stream bed, acting on the face of the abutment; and P_6 is the weight of a strip of abutment one foot thick reduced for buoyancy of the submerged portion. These various forces when combined, produce a resultant action, R on the base of the abutment having a magnitude of 84,000 pounds and passing altogether outside of the base instead of cutting it near the centre as it should in a properly designed abutment.

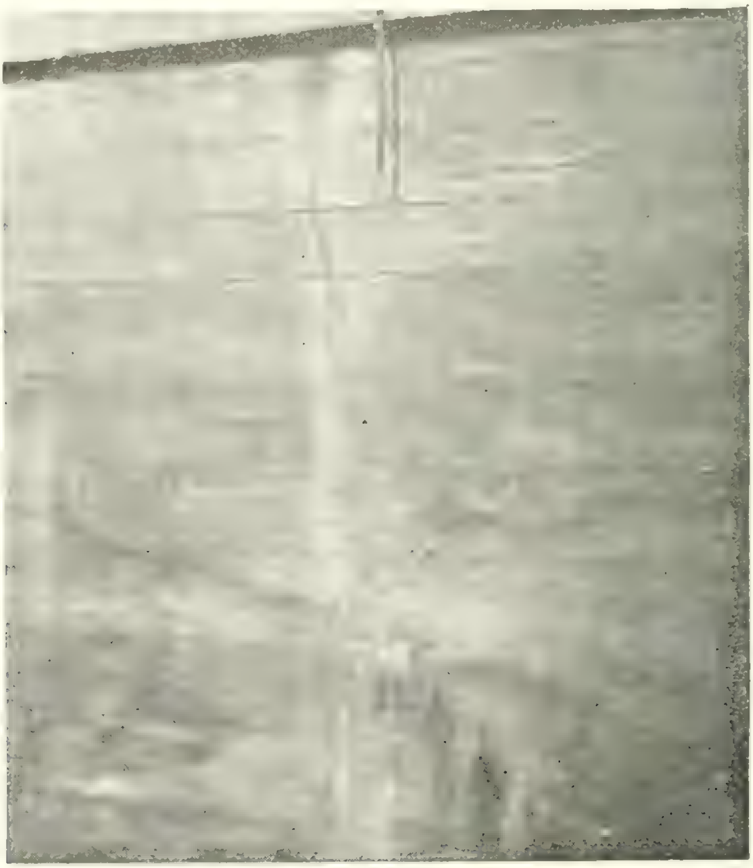

Fig. 7.

With the aid of Fig. 8, the spandrel cracks in this arch are therefore not difficult to explain. If the abutment were merely a simple block of masonry acted upon by the forces indicated in the diagram with no others operating, it would overturn about the lower right-hand corner; but, the presence of the spandrel walls with their reinforcement supplies sufficient resisting moment to preserve equilibrium, although not without overstressing them and causing the very pronounced cracks indicated.

Apart from the obvious effect of this serious error in the design, it is probable that spandrel cracks would have still occurred, although not to the same extent, as shown in Fig. 6. The abutments, as has been noted, were founded on vertical piles driven into quicksand, and under the thrust of the unusually flat arch lateral yielding of the piles would in all probability have been followed by cracking of the spandrels. The practice of founding arch abutments on piles, none of which are driven on a batter, or where no abutment ties are employed, is in the majority of cases likely to result in unsightly or dangerous cracks.

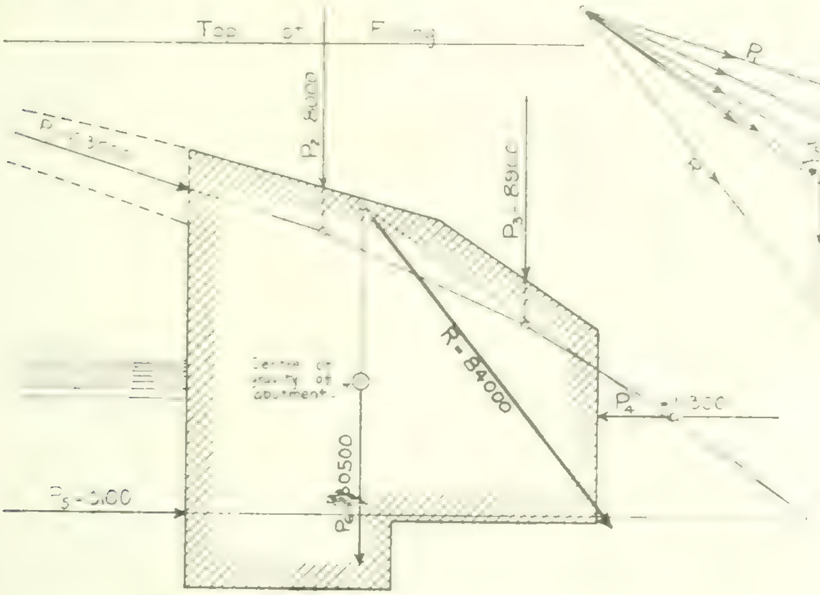

Fig. 8.

Spandrel cracks are so often found in concrete arches that their presence cannot always be attributed to badly designed abutments or to yielding foundations. The writer knows of one case where spandrel cracking occurred in an arch the abutments of which were founded upon solid rock and where, it is believed, the design was in general satisfactory. The spandrels, however, contained no longitudinal reinforcement, and the settlement of the crown when the centres were struck, had induced sufficient negative bending moment in the spandrels near their junction with the abutments to overcome the tensile strength of the concrete and cause conspicuous cracking. In all probability no such development would have taken place if the spandrel walls had been well reinforced, certainly not with properly designed arch ring and abutments.

The objectionable practice of inserting gas pipe or other metallic hand-rails in the spandrels of arches, strongly favors the development of spandrel cracks. Since the temperature of the exposed metal rises more rapidly than that of the concrete under the heat of the sun's rays, the posts expand more rapidly than the concrete and cause cracking of the latter at every post, which apparently increases with time on account of the swelling action of the rust at the surface of the spandrel wall.

CASE 11.

The badly cracked wing wall shown in Fig. 9 is typical of a greater number of like cases which exist throughout the country. Such a development does not, of course, put the bridge out of commission, but it necessitates the expense of shoring and repairs and at the same time provides a never-failing stimulus for remarks uncomplimentary to engineers. The source of the trouble is generally in bad design, and sometimes in careless workmanship. In this case, the wing wall is about 24 feet high, three feet thick at the base and 18 inches at the top *with no reinforcement whatever.* The workmanship and materials were good

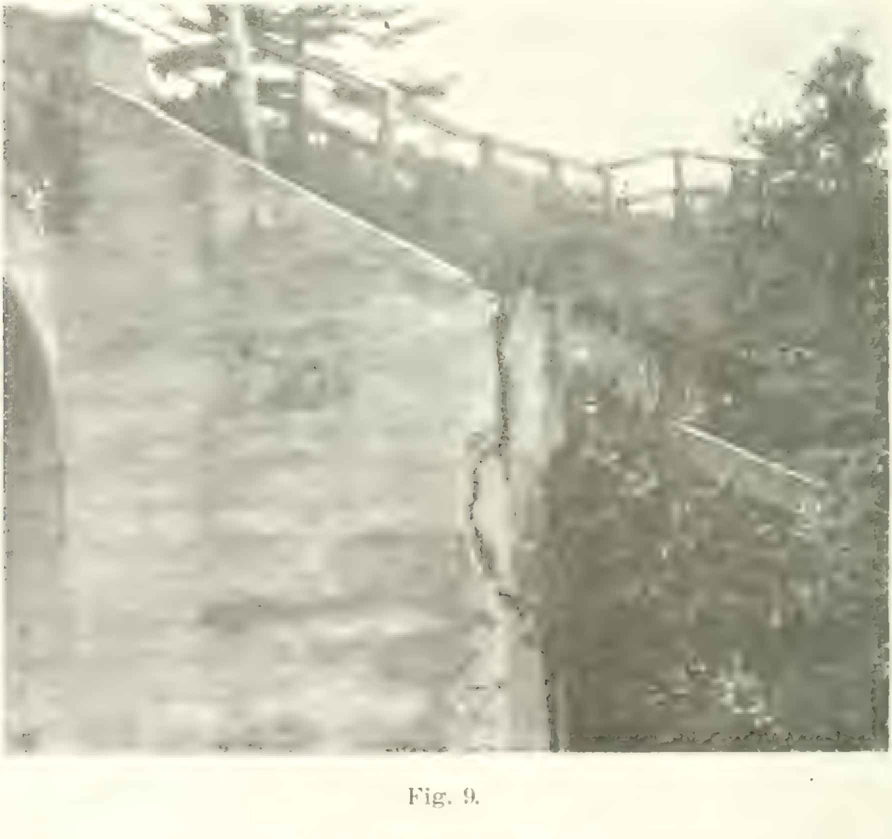

Fig. 9.

and the failure is therefore entirely due to the proportions of the wall. A number of cases of cracking of correctly designed wing walls at their junction with abutments are known to the writer, where trouble might have been avoided by a small amount of horizontal reinforcement at the corners.

CONCLUSION.

Summing up the eleven cases cited, the principal, and therefore primary causes of failure are found to be as follows:

Causes of Failure.	No. of Cases.
1. Design of foundations originally defective or rendered defective by alterations not approved by designing engineers	6
2. Design of superstructure defective	5
Total	11

It therefore appears that in cases discussed over one-half of the failures occurred from defective design of foundations. Especially significant is the fact that in the case of the two most extensive failures described, the original designs and specifications for the foundations were satisfactory and that the disastrous results were caused by alterations in the plans made by persons in authority without professional advice. The time is coming when engineers in self-protection will refuse to allow their plans and specifications to go out and suffer interpretation and alteration by laymen, but will insist upon the same expert attention to the work under construction as in the designer's office.

A feature of the above tabular statement which may occasion some surprise is the fact that in all of the cases considered failure was primarily due to errors in design, either of sub-structure or superstructure, and that the material, except to a limited degree in Case 2, was not in any way responsible for the unfortunate results.

It is perhaps unnecessary to remark that no special selection of cases was made for the purpose of this paper; but, every case has been included concerning which reliable data could be obtained in a short space of time. Since these cases are probably typical of most of the failures of concrete bridges, there does not appear to be any ground for the disquieting statements which have been made by interests antagonistic to concrete with the object of discouraging the use of the material in engineering works.

THE ENGINEER AND THE FINISHED WORK.

BY A. W. CAMPBELL.

Technical education is a subject receiving much attention in all progressive countries to-day. Germany has set the pace. She has shown what science and skilled workmen can accomplish. Her representatives are met throughout the world, gathering scientific information regarding raw materials, regarding systems of manufacture, regarding details of workmanship, in order that these may be available in "The Fatherland" in producing an improved quality of goods at a decreased cost. This is one of the great secrets of Germany's extending commerce—technical education. England has grasped this fact, and with the foresight and business instinct characteristic of the British people, we may confidently affirm that its usefulness will be tested to the full extent. Canada, in spite of the many demands upon its resources, is making progress in this regard, and governments and educational bodies are making substantial progress in the matter of manual training and the higher technical education.

This is a subject in which the engineer is keenly interested from a direct and personal standpoint. The result of his own education, of the labor, skill and care that he puts into his plans and specifications, are dependent upon the grade of workmanship available in securing ultimate results. His own skill and foresight are not sufficient, good material is not sufficient, if these are to be utilized wholly in a rough and haphazard way by untrained workmen and inferior inspectors.

The situation is one which every engineer in Canada must have at times keenly appreciated, when he has looked upon the defective work presumably carried out in conformity with his plans and specifications. Much of the engineering work carried on in Canada to-day is intentionally designed in an inferior manner simply because of the fact that we cannot depend upon the workmanship that is to be put into it.

The designing engineer cannot himself be always on the ground to give the necessary directions which even skilled artisans require, and between the engineer and the artisan lies the office of the inspector. The training of the engineer is necessarily made up of what we may roughly term "the practical" and "the theoretical." Both are essential. With the engineer on the one hand, the theoretical should predominate. With the inspector, the practical is necessarily the most essential feature. The inspector has need of both the theoretical and the practical if he is to properly interpret the engineer's intention and at the same time apply them in such a way that the contractor can accept in full his directions.

Contractors, however honest, are chiefly concerned in the profits accruing, not the perfection and durability of the work. The contractor's foreman is chiefly concerned in getting the maximum amount of labor for the minimum wage. His efforts are, of necessity, directed toward that phase of the work. It may be accepted as an axiom that the quality of the work cannot be wholly left to the contractor.

There is a great need in Canada to-day for skilled inspectors who will act as the connecting link between the designing engineer and the contractor. The inspector is not simply a watchdog on the work. He is there to fill a place which the contractor is not, cannot, be expected to fill. I would not separate wholly the work of the inspector from the profession of the engineer. I know of no better training for a young engineer than that experience, when, call him what you will, inspector, resident engineer, assistant engineer, he has the opportunity of remaining on the ground and studying all the details of practical workmanship. There is need, however, that young engineers prepare themselves for the inspector's duties in a proper manner, by a period of, let us say, apprenticeship.

Theory alone will not make a good inspector. As I have pointed out, the predominating qualification of an inspector should be the practical. He should know the different grades and qualities of material. He should know the different grades and qualities of workmanship. He should know how much work a man or men do in a day, and he should know as far as possible all those details of machinery and methods of doing work which tend to good and bad results.

This information is necessary to him as inspector, but doubly essential, it seems to me, for him to have a full grasp of, when, more closely following the duties of a professional civil engineer, his work will consist of the preparation of plans and specifications, in which he will be controlled and guided by the limitations imposed upon him by the grade of workmanship, the material and cost that are the tools with which he must ultimately get results. In Canada to-day we have splendid institutions of scientific education connected with our universities. We establish technical and manual training for artisans, but I would commend to you a more difficult school perhaps, but one in which the rewards are exceedingly satisfactory and gratifying, and which are absolutely essential to the highest grade of engineer. In this school he could start at the lowest rung and work his way up, as he has done in the School of Practical Science. The school to which I refer is the school of experience, in which, as with all other human endeavors the way is hard and difficult in proportion to the goal to be attained.

The inspector requires technical training, combined with experience, to interpret not so much the letter, as the spirit of the plans and specifications. The inexperienced technical student is, on the other hand, apt to be too particular over unimportant details; but the layman is careless and pliable in the hands of a determined contractor. A couple of seasons in a minor capacity, with two or three years technical study, is a training such as will enable an ambitious young man to become a thoroughly efficient inspector.

The Department of Public Works has frequent occasions to employ inspectors on works under contract. During the past season Mr. Arthur Sedgwick, a graduate of the School of Practical Science, was resident engineer or inspector in charge of the Kaministiquia River. These dams were in three sections, of concrete with considerable rip-rap, and when completed it will be possible to develop 40,000 horse power within a mile of the lake.

A work at Dryden on the Wabigoon River comprising a steel bridge of 80 feet span, concrete abutments 13½ feet high, and a filling 160 feet in length, rip-rapped, was supervised for the Department of Public Works by Mr. W. H. Manning, of the School of Practical Science. Mr. J. W. Hacker, a graduate, suprevised steel and concrete bridges at Nairn, Severn and Vermillion Rivers. The Vermillion bridge is in two steel spans of 150 feet each, with concrete substructure and a 300-foot timber trestle. The Nairn bridge is of steel, 200 feet long, on concrete abutments; and the Severn bridge was a concrete arch of 58½ feet span, built by Messrs. Gagne and Jennings. Mr. George Hogarth, of the School of Science, was inspector for the tunnel bridge on the Mississaga River north of Thessalon, a steel arch of 93 feet span, with a 60-foot steel trestle approach on concrete foundations. Mr. F. W. Robertson, of the School of Science, has made laboratory tests of cement for a number of works.

Technical men are not always available, so that we are compelled frequently to employ men of more or less practical experience, but without the theoretical training. Too often we find that these are men who do not value the work of the engineer or architect. To the layman, the architect or engineer is apt to be a man of fanciful ideas, who can write long specifications, and draw more or less intricate pictures, but who has no idea of how the work is to be carried out. The untrained man, lacking the basic information as to why the specifications require certain results, is wholly unable to determine how it should be done if he has not actually seen it performed in his past experience. In concrete, for instance, he has no conception of why the stone and sand should be clean, why they should be mixed in certain set proportions, why the mixing should be thorough. He blunders and stumbles along, hoping the results will be satisfactory, but he cannot give a positive assurance that they will be.

It is the unexpected that happens. No plans or specifications can be so prepared as to meet all emergencies. When something not contemplated by the plans and specifications occurs, the laymen's training is seldom equal to the occasion. His opinion of engineers and architects very frequently causes him to find a solution of his own. Lacking the knowledge as to why a thing should be done, he is incapable of determining how the emergency should be faced. When the engineer goes on the ground, it is too often to look with horror on the blundering work that has been carried out.

In making these statements, I am reminded that it is difficult to generalize. There are some competent laymen inspectors. But they are men who have grown up on practical work, who are shrewd observers, and have a native capacity that carries them beyond the ability of the average men. Inspectors of this class are rare, however, as they are usually employed as contractor's foremen, or graduate to the ranks of the contractor.

Towns and cities, all municipalities, are frequent offenders in the matter of inspection. Much municipal work has no inspection whatever. Inspectors, when employed, are apt to be local men with a little influence, who have been failures in their own line of work or business. They have great respect for the opinion of the contractor who is doing the work, and very little for the engineer who merely designed it. The inferior results and failures throughout the Province in municipal improvements are the unfortunate verification of this situation. When failure occurs, the public look to the engineer as the responsible official, and the reputation of the engineering profession has suffered much in consequence.

Men without technical training but with experience as contractors in carrying out works under an engineer's plans and specifications, are often looked upon as being highly capable of supervising work under other contractors. These men as contractors may have been eminently successful, the result probably being that they were obliged to follow carefully prepared plans and specifications, and were assisted in the execution of the work by skilled and competent inspectors. They, not being technically trained men, must not be assumed to be as capable as inspectors, because of the absence of that necessary technical knowledge without which the inspector cannot possibly interpret the intention of the designer or understand the reasons for the details of the design or the carrying of these into practical execution. Inspectors, as with engineers, mechanics and other skilled workmen, are competent and capable as the result of their genius, knowledge and training, and anything short of this is liable to result in the condemnation of the design, to reflect upon the materials used in the construction, and entail loss to the investors.

These are some of the difficulties which we have to face in carrying on public work. The situation is possibly one which can never be wholly overcome, but we are looking to the technical schools and colleges to supply us with men who will have the necessary practical and theoretical training, and we are at the same time educating public opinion as to the necessity of spending more upon the expert supervision of these works. The public are slow to grasp the value of expert services, and it is only with costly experience through mistakes and blunders of untrained inspectors, that these matters will ultimately adjust themselves.

I am not speaking in the interest of technically trained men but, being a public official charged with the handling of public funds in connection with public works, I have reached these conclusions from years of experience, and deem it but right that I should give the public the benefit of this experience, and warn them in the interest of good workmanship and economy. Sentiment has been, and to a large extent is, in opposition to skilled inspection, and where we apparently have difficulty in raising money for doing these necessary works, it seems difficult to understand why the public should persistently refuse to adopt the methods that will secure the most successful results.

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HIGHWAY BRIDGE CONSTRUCTION.

BY CHARLES TALBOT.

In Ontario, previous to 1874, the bridges on highways were almost all constructed of wood. From 1874 to 1895 many of the larger bridges were replaced with what were then considered permanent bridges. They consisted of quarry stone abutments and piers, costing from $9.00 to $12.00 per cubic yard, and iron and steel superstructures with wooden joists, floors and hand rails. In Western Ontario a large number of these were built to carry an equally distributed load of 80 pounds per square foot, floor surface, and a concentrated load of five tons on two axles at ten-foot centres.

Between 1874 and 1891 eighteen of such bridges were erected in Middlesex County, sixteen over the River Thames and two over the Ausable River, at a total cost of $227,000. They were designed with a large factor of safety, consequently they withstand the heavier traffic they are now subjected to, but they are too light to be floored with concrete. About 1896 the first concrete abutments and piers were built. At this time concrete was looked upon as an experiment, and stonework, even at an advanced price was preferred; soon, however, concrete was adopted generally, and in 1899 highway bridges were built with steel superstructures, designed to carry concentrated loads of 10 to 15 tons; supported on concrete abutments and covered with concrete floors. At this time they considered these structures permanent, and they are splendid works.

In 1903 short span concrete arches were built extensively. Then followed in quiet succession reinforced arches, reinforced beam bridges, reinforced abutments, until at present reinforced concrete is claimed to be the only permanent job, and whether permanent or not, one thing is sure that the remaining wooden bridges must be renewed in the very near future and in their renewal reinforced concrete is going to be used to a very great extent.

Such being the case and knowing that even the poorer classes of work hang together and will remain with us, it becomes us to look well at the details of the work to be undertaken, to see that the work is well done and that the structures erected are attractive in appearance, and substantially built in every particular.

A municipality should employ an experienced man to design their work. If the work is done by day labor, employ an experienced foreman, who will follow in every respect the design decided upon and carry out the plan and specifications. In no case should foreman, inspector or contractor alter the engineer's plans. If they discover something incomplete or that they consider wrong, they should notify those in charge and the engineer should be consulted. If he is a man you should employ he will welcome the criticism and will admit his mistake if he has made one and will know how to rectify it, so as not to interfere with other parts of the work.

If you do your work by contract, employ a reasonably efficient contractor and an experienced inspector, if you can get one; if not, at least get a man who will understand perfectly the plans and specifications and who will follow instructions given.

With an engineer and an inspector who understand their work and a good contractor, success of your undertaking is assured. There is absolutely no doubt as to the effectiveness of reinforced concrete when properly handled. Notwithstanding this there are a few jobs erected from plans prepared by me that are as complete as I would wish, in strength they are all that I expected, but their finish is not artistic. Out of the large number of structures I have designed few indeed are finished in accordance with the plan they were supposed to comply with. Only in two or three instances have the details of the finished work corresponded to the plan.

The difficulty is the lack of inspectors who understand the plan, and of contractors who understand the work.

However, we need not be surprised at these results when we know few contractors have erected more than two or three bridges and the great majority of them but one. Our men are improving, and this year I hope for much better results.

I have said little or nothing about the advantages of concrete. At this stage of its development its usefulness is universally admitted. I do not consider it as being in opposition to steel structural work, each is incomplete without the other, and an experienced engineer on highway work can readily determine whether a steel superstructure, an arch or a reinforced concrete superstructure, could be most advantageously used.

Under exceptional conditions long span arches can be used within reasonable cost. In my practice I have used reinforced concrete slabs up to 16 feet span, reinforced concrete beam bridges up to 36 feet span, reinforced concrete arches up to 75 feet span. Steel superstructures with concrete floors and concrete substructures in spans from 20 feet to 240 feet.

Since 1901 Middlesex County has spent $189,400 on bridgework alone, an average of $23,000 per year. In every structure erected concrete has been used, and has given complete satisfaction. The first concrete floor laid, 1902, is as perfect as when the maker left it.

I believe it is not in the interests of cement manufacturers or concrete workers to attempt to compete in price with steel highway work. The properly designed, well erected and artistically finished concrete structure is so much superior to the ordinary steel bridge that there should be no comparison in first cost. In my opinion it is this unequal competition that is causing the failure in concrete structures, in that on spans of any considerable length the designer cannot compete with steel under present conditions and allow sufficient factor of safety.

A superior article commands a superior price. Just as the old wooden bridge was not abandoned because timber became scarce and expensive, but because the people demanded a superior article at an advanced cost. So steel bridges, to a certain extent, are being superseded by reinforced concrete, not because it is less expensive but because its durability is established.

In 1908 and 1909 Middlesex County spent $100,000 on permanent bridges and road construction, this money was all paid out of the current revenue. I believe this is the plan followed in nearly all the townships and counties of Western Ontario.

In my opinion this is an unfair and unbusinesslike method to finance such undertakings. I think it unfair because the lease holders for the then current year pays for the whole of the bridge or work, while it will be used by future tenants for all time to come at his expense. It is unfair to the man who has his farm mortgaged, for he would be assisted in his financial affairs if he were allowed to pay a portion of his taxes and the balance at, say, 4 per cent., spread over a number of years.

It is unbusinesslike, because the wealthy is paying cash for taxes, that if left unpaid would not decrease the value of his property and would have to be paid by his successor in case he sold his farm. Also, such a method causes an abnormal increase in the current year's taxes which has a direct and detrimental effect on the selling value of the property and to keep down the tax rate, the municipal representative builds the inferior structure.

The legislators who framed the Act for the Improvement of Public Highways, which Act is intended to encourage the use of advanced methods, very properly had these conditions under consideration and until the representatives of the rural municipalities avail themselves of the provisions provided therein and issue debentures, they should, in my opinion, hesitate to undertake extensive works.

Were I to offer advice it would be to continue to adopt the designs in bridge construction that come the nearest to permanent structures, even at an advanced price. I would go farther and grade, drain and gravel the side-roads and concessions, but I would not attempt to pay for it out of current revenue, but would see to it that future generations would pay a large portion of the cost.

It is well known that both steel and concrete bridges are being designed and erected by the score by men who have neither scientific or practical knowledge of the subject, taking this into account and also the fact that reinforced concrete has been in use but a short time, the wonder is that more structures, especially of concrete, have not failed. The public should be protected from this danger and the least the Legislature could do and what there is great necessity for their doing is to establish some central supervision of all highway bridges before they are permitted to be used.

I have referred to the fact that the work done on reinforced concrete was not as good as it might be. However, in every case the structures being built are strong and substantial-looking, so much so that the municipalities that have erected them want more of them, and where possible, I have no hesitation in complying with their wishes.

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THE USE OF CONCRETE IN THE CONSTRUCTION OF PAVEMENTS.

BY JAMES PEARSON.

The "Scientific American" gives the definition of a pavement as "a covering composed of some durable substance laid on a street or road to keep the surface uniform and maintain it in a condition capable of sustaining traffic."

There is no branch of applied science that has in recent years made more progress or arrived at a state nearer to perfection than that of civic road making or the construction of pavements.

To-day we have the outcome of this progress evidenced in the up-to-date asphalt and other smooth-surfaced pavements laid on an unyielding, rigid and durable foundation—pavements easily repaired and capable of being kept absolutely clean and healthful by flushing or washing, and furnishing to the citizens the greatest possible facilities, convenience of and comfort in travel, both for vehicles and people on foot, and at the same time adding greatly to the beauty and general appearance of our streets.

No matter how fine the architecture of a city may be, without neatly constructed, clean pavements, the effect is lost. Such pavements will hide a multitude of architectural defects. Have you ever observed the wonderful change that the substitution of an asphalt or other up-to-date pavement for an old and neglected macadam roadway has on the general appearance of a street? The residents immediately take an interest in their premises and set to work to add to the general appearance by planting trees, sodding the boulevard, etc., so that in a very short time one would scarcely recognize that it is the same street.

So much has the importance of up-to-date pavements in towns and cities become recognized as essential to the improving of the general appearance of the place and aiding in and evidencing its enterprise and prosperity, that they all seem to be engaged in an effort to outdo each other in the matter of pavements, and thus our towns and cities during the past few years are taking on a vastly improved condition, much to their own convenience and comfort. They have found that money spent in this way, in addition to other advantages, has added much more than the cost to the value of their properties.

Nor is this ambition for high class pavements confined to the larger centres. It has spread to the smaller towns, even those of five and six thousand inhabitants, with faith in the prosperity and future of the country and seeing the great assistance to the progress of a place good pavements are, become possessed of the idea of having at least their main streets properly paved.

As an evidence of the progress that is being made in this respect, I may mention that in Toronto alone in 1908 (the figures of 1909 not yet being compiled) there were laid 25 miles of pavements on a concrete base or foundation consisting of 21 miles of asphalt and four miles of other kinds, such as brick and asphalt block, and all with a concrete curb and gutter except the brick, which has a curb but no gutter. In the same year there were laid 55 miles of concrete sidewalks, making a total of 340 miles of such walks in that city up to the end of 1908, and 1909 had about as much concrete paving work done as 1908. Toronto has now about 120 miles of asphalt pavements all laid on concrete varying from four to six inches in depth.

Other towns and cities are making corresponding progress and using enormous quantities of cement in the work.

So much as to what has been and is being accomplished in the way of improvement in the quality of pavements and the great interest being taken in the subject and the increasing area that is being laid.

It will be my object in this brief paper to endeavor to show how these greatly changed conditions were effected and the important part played by Portland cement or concrete in the bringing of them about.

Going back, we find the first important step towards impavements in road making was the invention of John L. Macadam who, in or about the year 1818, devised the road made of broken stone which is still known by his name, and so far as country roads are concerned, it is still the recognized standard all over the civilized world, and when well laid is a good one for country use, but when heavily travelled requires constant repair, and since the advent of the motor car will be still more difficult to keep in good condition.

Although no change has been made up to the present time in the construction of the macadam road, this device did have something to do in the development or evolving of the ideal smooth surfaced pavement, with concrete foundation, of the present day, and this is how it occurred:—In the district of Val de Travers, Canton of Neuchatel, Switzerland, macadam roads were made of a broken brown bituminous limestone. Under the pulverizing effect of the traffic and the influence of the sun in softening the bitumen the surface of the pavement became welded together in a continuous sheet, and in 1854 the first pavement of this material was laid in Paris on Rue Bergere, and this is what is known as rock asphalt, now so extensively used throughout the cities of Europe. It is also known by the name of Val de Travers. It has also been used to some extent in some of our own Canadian seaport towns and Ottawa, but the cost in comparison with the use of Trinidad and other American asphalts which have since come into competition, makes its further use in America prohibitive.

The success of this bituminous rock as a pavement led a French chemist named Edward De Smedt to analyze it, and he came to America in 1870, and among his experiments to devise a practical paving material similar in effect to the Neuchatel bituminous rock, but less expensive, he tried the use of a mixture of Trinidad asphalt with sand, and laid samples of pavement with it in several American cities to keep alive his patent. In 1877, on Pennsylvania avenue, in Washington, between the White House and the Capitol, outside of some samples referred to, was laid the first asphalt pavement in America. It took the place of an old wornout wooden one, which had supplemented a previous macadam. The history of street paving on this continent:—First the earth road or turnpike rounded up with a ditch at each side on corduroy; then the macadam or gravel, sometimes if the ground were soft, as a foundation it was constructed on a layer of split cedar logs. After this came the wooden block, and when sawn in rectangular shape, laid on a tarred board foundation two layers of inch boards crossed, such as was the wooden block pavement laid in Toronto over thirty years ago on King street from Yonge to York. But our experience of wooden block pavements was mostly with the round cedar blocks cut from the log and laid on either tarred boards or on a bed of sand and gravel, mostly the latter, and a wretched experience it was. There was also the cobblestone pavement—roughest of all, and where the cost could be borne, as it was expensive, stone blocks of granite or sandstone, were resorted to. Such were the devices and makeshifts adopted before, and leading up to the modern and present day permanent pavement.

But the subject in hand, viz., the use of concrete in the construction of pavements:—

In experimenting it was found that the use of asphalt, whether Val de Travers, Trinidad or any other, it was only serviceable as a surfacing material and to make a pavement with it a firm and rigid base or foundation was absolutely necessary. As a surfacing material, smooth, easily kept clean and repaired, sand and pulverized limestone mixed with sufficient asphalt to cement them together, made the nearest approach to the ideal pavement surface that had yet been hit upon, but it was absolutely useless without a rigid base to support it, so a cement concrete was tried and found to meet the requirements and thus the use of concrete originated as an asphalt pavement base.

Noting the utility and success that attended concrete as a base or foundation for asphalt pavements, it has been adopted generally by civil engineers as a base for most other pavements such as brick, vitrified block, asphalt block and even granite block is now laid on concrete, as experience proves that it gives and maintains a more even surface to any class of pavement.

As a base it has many advantages over any other foundation. On streets where the subsoil has been cut and disturbed by putting down sewers, water and gas pipes and making connections with buildings and where a settling is likely to take place, a good five or six-inch concrete will maintain any ordinary traffic even if unsupported at these cuts. Its use has also entirely supplanted the use of stone in curbs and gutters and with great economy as to cost, a stone curb and gutter that would cost about $1.00 per lineal foot can be laid for half that cost with cement, while the latter far excels the former in durability and appearance. Stone curbs made of straight blocks do not compare in appearance with the graceful curve of a concrete construction on a winding street, nor will stone curbs remain in position no matter how well set owing to the depth of the frost in our cold winters. The recognized construction of concrete curb and gutters now is to have them constructed on the concrete base and at the same time. This saves material and forms one solid body consisting of base, curb and gutter. Sometimes when the sidewalk is constructed before the pavement and is placed out adjoining where the pavement is to be, the curb is built as a part of the walk and is then made of sufficient depth to form a curb to the bottom of the base of the intended pavement.

As a base for pavements concrete has another advantage in that it can be laid on ground that is wet and even soft, as moisture only improves its quality, and being a solid body it will bear up the traffic even if there are weak spots underneath. Its use is now revolutionizing the construction of those parts of street pavements occupied by street car lines or tracks. Heretofore the rails have been almost entirely laid on wooden ties resting on the ground. With the modern large street car and heavy traffic, tracks so laid are continually sinking so that the rails have at great expense and inconvenience to traffic, to be frequently shimmed up to keep the motors underneath clear of the pavement. But by the use of concrete under the ties or under the rails without ties a rigid and permanent track can be had and the pavement between the rails kept even with that on the outside, thus giving the whole street an even and durable surface except as to the groove for the flange of the car wheels to run in.

These are some of the advantages recognized in the use of concrete as a base for the modern pavements, but the greatest of all is its durability. It is permanent, so that when the wearing surface wears out, which in time all wearing surfaces will, it is still there as good as ever ready for a new top—and thus it is in the end the most economical. In fact, so generally recognized has concrete become as the proper base for all the best pavement that the proper definition for a permanent pavement as distinguished from others may be said to be a pavement having a concrete base. And right here I would tender some advice to the small towns that are raising funds for permanent pavements on their main streets, that no matter what surface they adopt, whether asphalt, asphalt block, brick or bituminous macadam, they should insist on a concrete base. In this they will then always have a valuable asset—a base that can be resurfaced from time to time after the first one wears out. It will prove to be the most economical in time.

With regard to the use of concrete as a wearing surface, while it is recognized as the most excellent material when properly made, for all sidewalks, presenting a beautiful surface that wears evenly and is more durable than stone, except perhaps granite, yet it does not form a good wearing surface for a busy street with much vehicular traffic with iron tires. It has no resiliency and is too brittle, and when it wears uneven by reason of the constant beating of the iron tires and horses' shoes, it is difficult to repair. In fact the quality, rigidity which makes it a perfect base militates against its use as a wearing surface. This conclusion is not mere theory for it has been tried as a wearing surface. About fifteen years ago a street half a mile in length was paved with it under the "hyfaluting" name of Silica Bayritic, but even the name did not save it from wearing into ruts and holes within two years. There is also a pavement of it on a short street in Toronto laid about ten years ago, not a success. But it is now being adopted rather extensively for paving lanes and areas where there is little traffic.

If the time should come when increased travel by the rubber tire motor car should demand roads set apart for their exclusive use, a concrete pavement would, I believe, make the ideal one.

In conclusion I may add that the recently reduced price of Portland cement in comparison with former years will add an additional incentive to the use of this most valuable material in the construction of modern pavements and the beautifying of our towns and cities.

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SOME EXPERIMENTS WITH CEMENT TILE.

BY PROFESSOR W. H. DAY,

Of the Ontario Agricultural College, Guelph, Ont.

Since the Ontario Agricultural College began college extension work on the subject of farm drainage, some five years ago, there have been numerous enquiries for information on the subject of cement tile. People usually wanted to know two things, first, whether the cement tile could be made cheaper than clay tile, and, second, whether they would be durable. When these enquires first began to come in, there were not, so far as I am aware, any extensive or conclusive data as to the durability of cement drain tile, nor was there any grave question about their durability. There was a general impression, however, that they should prove durable, judging from the manifold conditions in which concrete had proven its usefulness. Therefore, at first we concerned ourselves with the cost of manufacturing cement tile by hand, for the point made by most of the enquirers was that they were thinking of procuring moulds and making their own tile.

For use in our experiments on the cost of manufacture, the London Concrete Machinery Company furnished us with one of their two-piece cement tile machines, since taken off the market. And the experimentation was undertaken by Mr. A. M. Shaw, one of our students, who had had considerable experience in cement work with his father, the late Mr. Robert Shaw, of Niagara Falls, Ont., who for several years did much of the road contracting in his locality. During the months of April and May, 1908, experiments were conducted in making cement tile.

While writing the report of these experiments in the latter part of the year, we learned of the controversy over the durable cement drain tile, and we must confess that the idea of cement being soluble was a new one to us. After reading the attack on cement and the answer to it, we councelled our farmer to go slowly in the adoption of cement tile, believing that the uncertainty, in our own minds at least, about their durability was sufficient to warrant such action. At the same time, however, we decided to conduct some tests in order to learn for ourselves something about the solubility of cement, and to deduct from the information thus obtained some idea of the probable durability of cement tile. These experiments were begun in February, 1909, and have been continued until the present.

Besides the points already mentioned, the porosity of cement tile received some attention during our experiments.

THE COST OF MAKING CEMENT TILE BY HAND.

The tile made by the London two-piece machine were hexagonal on the outside, being about three-quarters of an inch thick in the thinnest part and considerably thicker at the corners. Mr. Shaw found that, mixing his own material, he could make a shade over 500 complete three-inch tile in a day when everything was once in order. The material had to be mixed quite dry in order that the mould might clean, so dry indeed that it was impossible to tamp it close enough to make a compact tile. By oiling the moulds it was found that the material might be mixed much wetter, but still not wet enough to make what we consider a good tile. We also thought that considerably more material was used in the tile than would be necessary for a round tile; and besides, the amount of handling required for two-piece tile was double that for one-piece. These features led us to doubt this type of machine would ever be popular with the farmers. On consultation with the company, we found that they had arrived at the same conclusions, and that they were withdrawing the machine from the market. These circumstances at first led us to think that the work done on this phase of the problem was of little practical value, and we discouraged the extensive publication of the results, although we placed them in our annual report, just as a matter of record. On second thought, however, we have changed our minds somewhat, for the following reason: The rate of manufacture determined must represent fairly well what might be expected with a round-tile machine of similar dimensions; the round tile would be slower to tamp but there would be only half as many pieces to handle. And as a matter fact, we have since learned of a hand machine for round tile, recently invented, on which one man can make about 500 tiles a day, thus establishing that the rate of manufacture determined in our experiments, in all probability, is a fairly representative one.

We found that 6 cubic feet of sand and 1 bag of cement (approximately a cubic foot) would make 78 complete 3-inch tile. But a round tile one-half inch thick requires only 55 per cent. as much as the one made on the London two-piece machine, hence the material mentioned above would make $\frac{100}{55} \times 78$ or 142 tile, providing they were tamped to the same compactness. As they could be made wetter, they would likely be somewhat compact. This, however, would be counterbalanced by the use of another half bag of cement, making the proportions 4 of sand to one of cement (6 to 1 is too poor for really strong tile), so that we may fairly assume from our figures that from 6 cubic feet of sand and 1½ bags of cement there can be made 142 3-inch tile, say 140 in round numbers. This gives us a means of arriving at an estimate of the cost of making 3-inch tile, one-half inch thick, by hand, when the price of material is known. In Guelph we pay $1.00 a yard for sand and $1.90 for cement. At these prices—

6 cubic feet of sand cost	$ .22
1½ bags of cement cost	.71
Total price for material for 140 tile	$ .93
Total price of material for 500 tile	3.32
Wages of man for 1 day	2.00
Total cost of 500 tile	$ 5.32
Total cost of 1000 tile	10.64

In this estimate no allowance is made for hauling the material as this can be offset against the hauling of clay tile, if it is desired to make a comparison between the cost of the two kinds.

The prices used in this estimate may be high in some localities; but, knowing that 6 feet of sand and 1½ bags of cement will make 140 tile and that a good man can make about 500 tile a day on certain types of machine, the cost of manufacture may be figured out to suit cost of materials in various localities. Or again, if the type of machine is such that a man can make only 400 instead of 500 in a day, the cost of the tile can readily be calculated.

Next we come to the solubility tests—

EXPERIMENT 1.

Sample.—A piece of cement tile weighing 43.256 grains, after being dried to constant weight at 215° F. This tile was made by the "dry process" in April, 1908, in proportions of 6 of sand to 1 of cement. For a few days after being made it was watered daily, and then it was submerged in water for a period of six weeks, after which it was removed to a storage cellar, where it remained until solubility experiments began. Tile quite porous.

Treatment.—After the small piece had been dried to constant weight, it was placed in distilled water for four days, then removed, dried, weighed, and again placed in fresh distilled water. As convenience allowed, it was dried, again weighed, and once more placed in fresh distilled water. This was repeated sixteen times, the total period of solution being 143 days, and the total loss in that time was .113 grains. The total cement in the sample was 7.1794 grains, hence at this rate the cement would all dissolve in 27.7 years.

The experiment was next performed with water from the artesian wells at the College. This water is high in total solids, about 480 parts per million, made up chiefly of bicarbonate of calcium, bicarbonate of magnesium, or the compound bicarbonate of calcium and magnesium. There is also a small amount of chlorine in it. The sample was tested five times in this water, the total period of solution being 47 days and the total loss in weight .090 grains. At this rate it would take only ten years to dissolve all the cement in the sample.

EXPERIMENT 2.

Sample.—A piece of tile, proportion of 6 to 1, made on London two-piece machine, May, 1908, watered daily for a week, after making stood in cellar till November, 1909, mixed much wetter than sample used in experiment, so wet that the moulds would not clean well. Dry weight, 43.213 grains.

Treatment.—Same as sample in Experiment 1, only the number of tests in distilled water numbered eight instead of sixteen, the total period in the water being 73 days. During the period the sample lost .025 grains, at which rate it would take 57.4 years to dissolve all the cement in it. When put in the well water the loss in 42 days was .090 grains, which rate would use up all the cement in 10.3 years.

EXPERIMENT 3.

Sample.—A piece of wet-mixed tile, made the same time as No. 2, and watered and stored in the same way. Dry weight, 36.2795 grains.

Treatment.—Distilled water for 73 days, well water for 47 days.

Result.—This sample lost only slightly in distilled water and gained .0333 grains in well water. At this rate it would last forever.

EXPERIMENT 4.

Sample.—A piece of tile, proportions 4 of sand to 1 of cement, made by George Holden, of St. Mary's, on the London Automatic Cement Tile Machine. Watered daily for a week after being made, and then stored in our laboratory until October, 1909. Dry weight, 20.4792 grains.

Treatment.—Same as in 2 and 3.

Result.—Loss in distilled water in 73 days, .0387 grains. At this rate the sample would last 26.5 years.

In well water the total loss was .130 grains in 47 days, at which rate the sample would last only 5.1 years.

EXPERIMENT 5.

Sample.—A piece of tile, proportions 4 of sand to 1 of cement, made by same maker as No. 4, cured and stored in the same way. Weight, 35.781 grains.

Treatment.—Same as others.

Result.—In 73 days in distilled water the loss was .0175 grains, at which rate the sample would last 102.2 years. In 47 days in well water the sample gained .1065 grains in weight and thus would never disintegrate.

EXPERIMENT 6.

Sample.—A piece of clay tile, about average quality, possibly burned a little slack. Dry weight, 36.660 grains.

Treatment.—In distilled water 46 days, weighed five times; in well water 47 days, weighed five times.

Result.—Loss in distilled water 1.159 grains, at which rate the sample would last only 4.1 years. Loss in well water .081 grains, at which rate the sample would last 58.3 years.

In estimating the time that sample would last, it has been assumed that they would be subject to solution 365 days in the year and that the rate of solution would be uniform. The first of these conditions certainly would not hold in practice. During a large portion of the year, possibly half, tiles are dry and not subject to solution, and, consequently, would last twice as long as the periods mentioned, provided the rate of solution during the other half of the year was constant.

We had hoped to establish something definite as to the rate of solution, but we have failed to do so yet. The rate of solution seems to fluctuate with some factor other than time, probably temperature.

Just when our curve for rate of solution would reach a constant for two or three readings this variation would occur and prevent conclusions. In all samples, the rate of solution in distilled water appeared to fall off, slowly in most cases, but very rapidly in a few, especially in the case of the clay tile. Then, placed in the well water the samples all behaved irregularly at first, giving either large losses or else large gains and these losses or gains fell off rapidly.

Three other experiments were performed, which probably come nearer natural conditions than the previous experiments do. Three half tiles were placed in running well water on May 6th, 1909, where they have been ever since. At the end of six months they were dried, weighed and replaced in the water. Then last week they were dried and weighed again. The results are as follows:—

EXPERIMENT 7.

Sample.—A half tile, proportion 6 to 1, made on London two-piece machine, dry process, May, 1908, watered for a week, stored in cellar. Dry weight, 1797.5 grains.

Treatment.—In running well water for 10½ months, weighed at six months and at 10½ months.

Result.—Tile gained in weight each time. Total gain, 3.4 grains.

EXPERIMENT 8.

Sample.—Same as in 7. Dry weight, 1910.25 grains.

Treatment.—Same as 7.

Result.—No change in weight in first 6 months, a gain of 4.05 grains in next 4½ months.

These two samples would never disintegrate at this rate.

EXPERIMENT 9.

Sample.—A half tile, proportion 6 to 1, made on London two-piece machine, made very wet, so much so indeed that tile would not hold shape, and moulds would not clean. Allowed to dry, getting a few showers of rain, and then stored in cellar. Dry weight, 2001.0 grains.

Treatment.—Same as in 7 and 8.

Result.—Tile lost 1.90 grains first 5 months and 2.70 grains next 4½ months. At this rate the sample would last for 63.4 years.

It is worthy of note with regard to these three samples that those made by the dry process and, therefore, very porous, were the ones to lose.

The behaviour of these three large samples would seem to indicate that cement tile in the soil, subject to running water of low temperature, are likely to last much longer than would be indicated by experiments with smaller samples at room temperature.

It is our intention to continue the work on the solubility as we realize there is much yet to be learned about it.

POROSITY.

With regard to the porosity, we find that it varies with the proportion of cement, with the kind of sand used, and also with the method of making. The more cement used, the finer the sand, or the wetter the mixture, the less porous the tile. But even the most compact ones tested were much more porous than clay tile.

[*This Association is not responsible as a body for the opinions expressed in its Papers by Authors.*]

THE HARDENING OF PORTLAND CEMENT.

BY A. G. LARSSON.

The subject I shall treat in this paper is the hardening of Portland Cement.

Considering the technical importance of this process it must be admitted that it has taken an unusually long time to clear the mysteries surrounding the same. The reason must be sought in the fact that Portland Cement is not a body of the same strict chemical composition as, for instance, salt, Na. Cl., but one of a more changeable and complicated character. It is more like a solution of lime in silicates, aluminates a. s. f. than a salt in its common meaning. Besides this, the reactions taking place when it is mixed with water could hardly be explained intelligibly with the aid of the chemical science as this was a few years ago. Water is, as we know, necessary to make Portland Cement set. It would, therefore, seem probable the hardening would take place along the same line as is the case with Plaster of Paris. There we have an absorption of water and a transformation of it into crystal-water. This explanation must, however, be abandoned, because in hardened Portland Cement more deep-going chemical changes have set in. There is, for instance, always present a large quantity of hydrate of lime $Ca(OH)_2$, which is the result of the actions of water. This $Ca(OH)_2$ is found in crystals, a circumstance that led to an attempt to explain the hardening. The theory was advanced that the $Ca(OH)_2$ crystals were the cause of the hydraulic properties and the strength of cement. This explanation was accepted by most cement experts up to one or two years ago. It failed, however, to explain some of the most important phenomena in the mortar-technique. As, for instance, how could a Portland Cement resist the actions of water if its hydraulic properties and strength depended on hydrate of lime, which is soluble in water? It seemed also improbable that the aforesaid crystals could give the cement a tensile strength of 600 to 1200 lb. sq. in. Besides, why can a good hydraulic cement not be made without silica (SiO_2), if the silica does not influence the hydraulic properties? It is therefore but natural that both (CaO and SiO_2) have their mission to fill in the process of setting, especially as SiO_2 in combination with CaO gives compounds almost insoluble in water.

Dr. Michaelis, Sr., Germany, was the first to grasp this idea. After forty-five years of investigation on the subject, he laid, in a paper read last year to the German Association of Portland Cement Manufacturers, the foundation to a new theory, which, as far as I can see now, satisfactorily explains the hardening of hydraulic cements.

We know that energy is necessary to change matter or perform work. Now I claim that the manufacturers' first aim is to store up, at the lowest possible cost, a certain quantity of energy in the materials best suited for the cement. The energy is procured from the coals in the "burning." Energy may be expressed

E = fi × f c ;
fi = intensity factor
f c = capacity "

In the changes that take place in cement paste the intensity factor is represented by the solution pressure. This force drives the different atoms and groups of atoms into the water surrounding each particle of cement. *The solution pressure is necessary for the hardening.* The process it causes is, in chemistry, called *dissociation*, and the atoms or groups of atoms it forces into solution are, if they contain electrical charges, called ions. The ions of calcium and those of its compounds with silica and with the oxides, or rather the acids of aluminum (Al_2O_3) and iron (Fe_2O_3) are, in our case, the most important.

The solution pressure will, according to the laws for concentration-cells, decrease the more of the substance is driven out, *i.e.* the less the concentration is. As in our case, lime sends out most ions, the following formula will suffice :

I. $$p_1 = \frac{p(C - c)}{C} \text{ gr/cm}^2$$

p_1 = solution pressure in gr/cm² at a certain moment
p = initial solution pressure in gr/cm²
C = % CaO in the Portland cement.
c = % CaO that have been dissolved.

There is still another force to be considered. When the ions have entered the water they try to prevent others of the same kind from doing so, thus causing a reaction which is called the osmotic pressure. Its strength is in direct ratio to the concentration of the dissolved substance.

The activity of the hardening process at any moment depends on the comparative strength of the solution pressure and the osmotic pressure. The final result of the changes they cause will be a state of equilibrium at which point the hardening process is finished.

As I said before, the solution pressure is necessary to make Portland cement set. When it drives the different atoms or groups of atoms in solution or ion-state, a certain quantity of energy is active, and this quantity of the latter is, at a certain moment, a true indicator of the progress of the reactions at that moment. The energy may be expressed by Nernst formula :

$$2. \qquad E = R\ T\ \ln \frac{p_1}{p}\ \text{gr/cm}$$

E = energy in gr cm
R = constant – 84800
T = absolute temperature in C°
In denotes natural log.
p_1 = solution pressure in gr/cm^2
P = osmotic pressure in gr/cm

If we combine formulæ 1 and 2 and take into consideration some reactions which I shall describe later, the following formula is obtained for the dissociation of lime during the first part of the process :

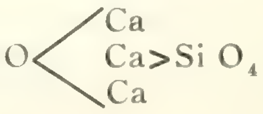
$$3. \qquad E = 1{\cdot}952 \times 10^5\ T \log \frac{p\ (C - c)\ (56\ n\ v - 18\ c\ (n - 1)}{O.\ 818 \times 10^5\ T\ n\ C\ c}\ \text{gr cm}$$

E = energy in gr/cm
T = absolute temperature in C°
p = the initial solution pressure in gr/cm^2
C = % Ca O in the cement
c = % Ca O in the solution v = % water used

After these preliminary preparations we are now able to follow and explain the process of hardening. As I said before, when water is added to the cement the lime is forced into solution as $\overset{\cdot\cdot}{Ca}$ by the solution pressure. Referring to the supposition that the energy is an indicator of the progress of the reaction, we see from Nernst formula that the activity of the process increases with the ratio between the solution-pressure and the osmatic pressure. I may now point out that we have here the explanation of our retarders, gypsum, Plaster of Paris, and calcium cloride. These have a large dissociation-velocity and therefore drive into the water $\overset{\cdot\cdot}{Ca}$ ions before the cement has begun to react, thus causing an osmatic pressure. This counteracts, therefore, the solution pressure in the cement from the very beginning, and the result is naturally a slower set. Returning to Nernst formula we also see that the activity of the reactions increases with the temperature, which is in conformity with our experience ; cement mortars set quicker in hot weather than in cool. With the aid of formula 3 it can be proved that increase of water increases the setting time.

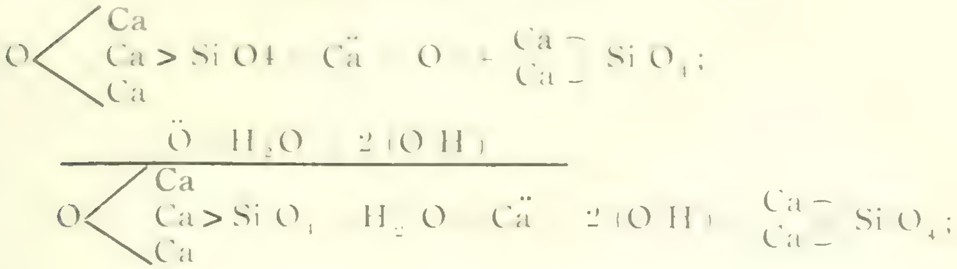
Suppose now that $Si\ O_2$ is united with 3 CaO, which is considered an ideal combination.

The compound may be written



$$O \left\langle \begin{matrix} Ca \\ Ca > Si\ O_4 \\ Ca \end{matrix} \right.$$

The dissociation of the same takes place as follows :



$$O\left\langle\begin{array}{l}Ca\\ Ca > Si\,O4\\ Ca\end{array}\right. = \ddot{Ca} + O'' + \begin{array}{l}Ca -\\ Ca -\end{array}\!\!\!\supset Si\,O_4 ;$$

$$\underline{\ddot{O} + H_2O = 2\,(O\,H')}$$

4. $$O\left\langle\begin{array}{l}Ca\\ Ca > Si\,O_4\\ Ca\end{array}\right. + H_2\,O = \ddot{Ca} + 2\,(O\,H') + \begin{array}{l}Ca -\\ Ca -\end{array}\!\!\!\supset Si\,O_4 ;$$

The dissociation does not, however, stop at this stage. The remaining $\begin{array}{l}Ca \frown\\ Ca \smile\end{array}\!\!= Si\,O_4$ possesses also a certain solution pressure, *i.e.* power to send out ions. This must, however, according to the law expressed in formula 1 be lower than the one that was active in the reactions written in 4.

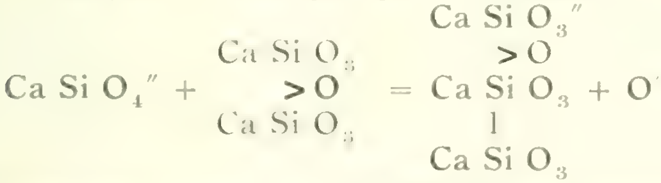
The dissociation of $\begin{array}{l}Ca \frown\\ Ca \smile\end{array}\!\!= Si\,O_4$ may be illustrated in the following formula :

5.

$$\begin{array}{l}Ca\\ Ca\end{array}\!\!> Si\,O_4 = \ddot{Ca} + Ca\,Si\,O_4'' ;$$

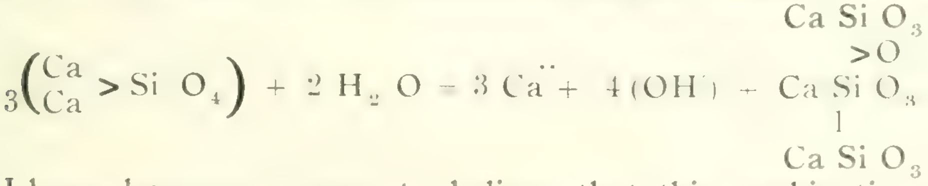
The Ca = Si O_3 has a very low solution pressure and the migration-velocity of Ca Si O_4 must also be small.

Another important matter to consider here is that silicon (Si) is related to carbon (C). Now, we know from the organical chemistry the many very complicated combinations of atoms that are formed by carbon. Taking these and other things which I shall point out later into consideration, I have come to the conclusion that Ca Si O_4'' ions combine with each other, as, for instance, $Ca\,Si\,O_4'' + Ca\,Si\,O_4'' = \begin{array}{c}Ca\,Si\,O_3''\\ >O\\ Ca\,Si\,O_3\end{array} + O''$. Another Ca Si O_4'' can join the last groups as follows :

6. 

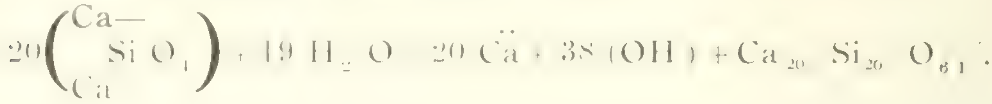
$$Ca\,Si\,O_4'' + \begin{array}{c}Ca\,Si\,O_3\\ >O\\ Ca\,Si\,O_3\end{array} = \begin{array}{c}Ca\,Si\,O_3''\\ >O\\ Ca\,Si\,O_3\\ |\\ Ca\,Si\,O_3\end{array} + O''$$

O'' unites with water to 2 (OH'). If only three groups Ca Si O_4'' combine the formula for the dissociation may be written :

7. 

$$3\left(\begin{array}{l}Ca\\ Ca\end{array}\!\!> Si\;O_4\right) + 2\,H_2\,O = 3\,\ddot{Ca} + 4\,(OH') + \begin{array}{c}Ca\,Si\,O_3\\ >O\\ Ca\,Si\,O_3\\ |\\ Ca\,Si\,O_3\end{array}$$

I have, however, reason to believe that this combination of ions takes place to such an extent that each group contains at least between twelve and twenty atoms of silicon. For 20 Si the dissociation may be expressed :

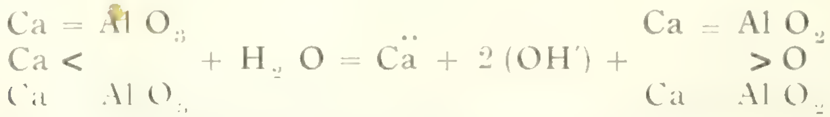
8. 

$$20\left(\begin{array}{l}Ca—\\ \quad Si\,O_4\\ Ca\end{array}\right) + 19\,H_2O = 20\,\ddot{Ca} + 38\,(OH') + Ca_{20}\,Si_{20}\,O_{61}''.$$

This is practically the last stage of dissociation of the silica-compounds.

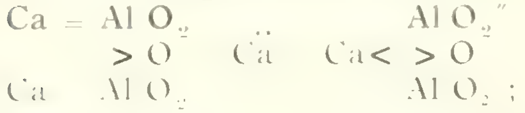
Let us now for a moment direct our attention to the combinations between the lime and the oxide, or rather acid of aluminum Al_2O_3. Their solution pressure is high when they are in the pure state, but when diluted, as in Portland Cement, it is, according to the laws governing concentration cells, correspondingly low. We know that the higher a cement is in Al_2O_3 the quicker will it set, or the more trouble are we having to make it slow. The calcium aluminates unite also with the gypsum forming an almost insoluble salt : $3\,CaO\,Al_2O_3 + CaO\,SO_3 + 28.5\,H_2O$.

The dissociation of the aluminates may be illustrated as follows :

9. 

$$Ca\begin{array}{l}= Al\,O_3\\ < \\ \;\;\,Al\,O_3\end{array} + H_2O = \ddot{Ca} + 2\,(OH') + \begin{array}{l}Ca = Al\,O_2\\ \qquad\;\; > O\\ Ca \quad Al\,O_2\end{array}$$

The next stage of the dissociation would be :

10. 

$$\begin{array}{l}Ca = Al\,O_2\\ \qquad\;\; > O\\ Ca \quad Al\,O_2\end{array} = \ddot{Ca} + Ca<\begin{array}{l}Al\,O_2''\\ > O\\ Al\,O_2\end{array};$$

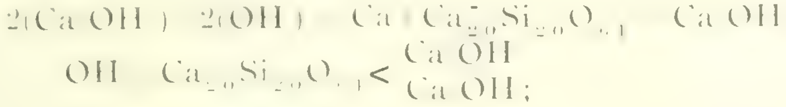
The negative ions (anions) of the aluminates will not, as a rule, combine with each other to such complex groups as is the case with silica. The oxide of iron combinations with lime dissociate like the aluminates. Their solution pressure is, however, lower.

As for the magnesia compounds their solution pressure is so low and the amount of them present so small that their dissociation takes place very slowly. This is the reason why Mg O is so dangerous. It hydrates under considerable expansion when the rest of the mass has set. If it then is present over certain limits it will cause cracks. I may, however, add that I have pats containing 22 Mg O which have been kept in water over four years and still are intact.

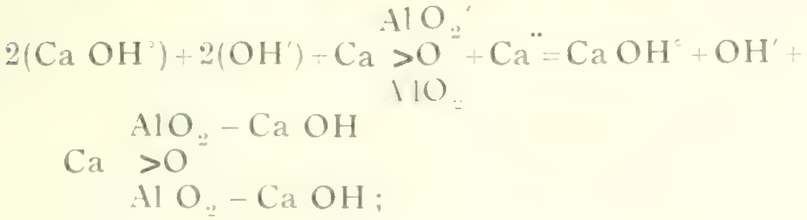
We have now seen that lime has been driven into the water from the various compounds mostly as $\ddot{Ca}$ + 2 (OH'). The point will then finally be reached where the combined actions of the osmatic pressures of $\ddot{Ca}$, OH_1 H and the two latters (O_2 H_2) solution pressures will cause $\ddot{Ca}$ to unite with O H' :

11. $\ddot{Ca} + 2\,(OH') = Ca\,OH^{\circ} + OH'$

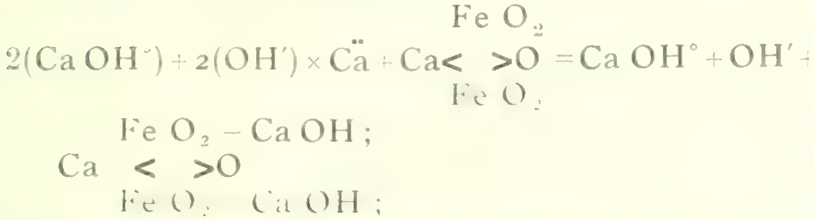
These ions will, in their turn, after acquiring a certain concentration, *i.e.* a certain osmatic pressure unite with the complex anions I mentioned before.

12.


$$2(\mathrm{Ca\,OH}^{\cdot})+2(\mathrm{OH}')+\ddot{\mathrm{Ca}}+\mathrm{Ca}_{20}''\mathrm{Si}_{20}\mathrm{O}_{61}=\mathrm{Ca\,OH}-\mathrm{OH}-\mathrm{Ca}_{20}\mathrm{Si}_{20}\mathrm{O}_{61}<\begin{array}{l}\mathrm{Ca\,OH}\\ \mathrm{Ca\,OH};\end{array}$$

13.


$$2(\mathrm{Ca\,OH}^{\cdot})+2(\mathrm{OH}')+\mathrm{Ca}\begin{array}{l}\mathrm{Al\,O}_2'\\ >\mathrm{O}''\\ \mathrm{Al\,O}_2\end{array}+\ddot{\mathrm{Ca}}=\mathrm{Ca\,OH}^{\cdot}+\mathrm{OH}'+\mathrm{Ca}\begin{array}{l}\mathrm{AlO}_2-\mathrm{Ca\,OH}\\ >\mathrm{O}\\ \mathrm{Al\,O}_2-\mathrm{Ca\,OH};\end{array}$$

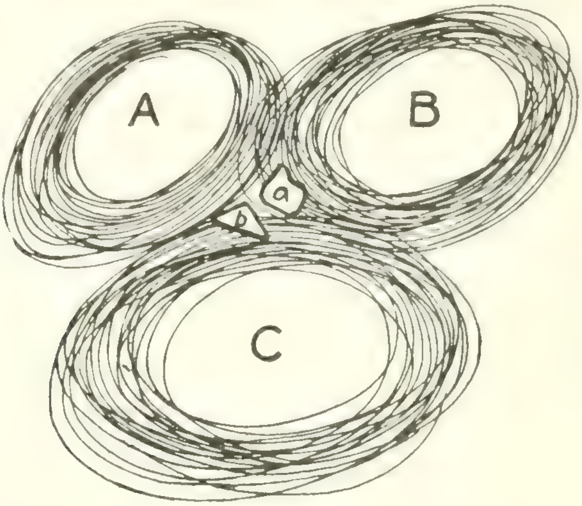
14.


$$2(\mathrm{Ca\,OH}^{\cdot})+2(\mathrm{OH}')\times\ddot{\mathrm{Ca}}+\mathrm{Ca}<\begin{array}{l}\mathrm{Fe\,O}_2\\ >\mathrm{O}\\ \mathrm{Fe\,O}_2\end{array}=\mathrm{Ca\,OH}^{\circ}+\mathrm{OH}'+\mathrm{Ca}<\begin{array}{l}\mathrm{Fe\,O}_2-\mathrm{Ca\,OH};\\ >\mathrm{O}\\ \mathrm{Fe\,O}_2-\mathrm{Ca\,OH};\end{array}$$

Of these reactions the one described in No. 12 is the most important, as it forms the so-called hydrogel. This calcium-hydrosilicate is practically insoluble in water. It is at this stage a clear, colorless, gluey mass, and could with right be called mineral glue. It absorbs water, thereby increasing considerably in volume. Besides these properties the hydrogel is semi-permeable, and accordingly allows the passage of water, but not of the dissolved lime, thus preventing the latter from escaping. From what has been said about this mineral glue we understand why the hydraulic properties of portland cement must be ascribed to it. The concentration at which it is formed has been found by Dr. Cabolet, Hemmoor, Germany, to be 1 part Ca O in 3300 parts water. If now all the lime were present as $\ddot{\mathrm{Ca}}+2(\mathrm{OH}')$, the osmatic pressure of $\ddot{\mathrm{Ca}}$ at 17° C should be = 133 gr per cm. I have, however, from determinations made on cement containing 63 Ca O calculated the initial solution pressure at 17° C and found it to be only 121 gr per cm^2. This is another proof that the dissolved lime will, at a certain concentration, change from divalent ions ($\ddot{\mathrm{Ca}}$) to monovalent ($\mathrm{Ca\,OH}^{\cdot}$) as expressed in formula 11. Of course, only a part is at first so transformed according to the laws of dissociation.

I have already pointed out some reasons why I claim that the negative part of the hydrogel is of a complicated structure. Its gluey consistancy is another, as we know from the organical chemistry, that the glues and like substance are composed of a great number of atoms. The following circumstance furnishes another proof for the complicated structure of the hydrogel. The amount of lime necessary to form the same is far smaller than would be the case if its anions had not combined, as has been said.

As for the calcium-hydro-aluminate and the calcium-hydro-ferrite their presence does not materially increase the hydraulic properties of Portland Cement, as they do not as a rule form mineral-glue, but crystals.



11. Suppose A, B, C represent grains of cement. They will, at this stage of the hardening (the formation of the hydrogel), be found surrounded with the mineral-glue which also fills the space between them, leaving only more or less room for the solution (indicated with *a* and *b*). The first part of the hardening is now finished.

The cement is, however, as is indicated in the figure, only partly hydrated. The process I have just outlined, *i. e.* the dissociation, is therefore still going on. The water necessary for the same is consequently taken from the surroundings. But as hydrogel does not allow the passage of the lime, the solutions in *a* and *b* will become more and more concentrated and $Ca\ (OH_2)$ will begin to crystalize. All the water in the cavities (*a* and *b*) is finally absorbed and the latter will be more or less filled with crystals, $Ca\ (O\ H)_2$. From now on the hydrogel itself is drying out. In doing so it acts just like glue. It shrinks considerably, and this gives the same a good grip on the particles it surrounds or is in contact with, be they grains of cement, sand or other materials. The strength is also increasing. The permeability for water is becoming less and less the dryer it gets and reaches finally zero. *Portland Cement is consequently waterproof.* We have now seen that Portland Cement has the property to dry out from within. This is an important fact that should not be overlooked, because, if we allow water to evaporate or be absorbed from the outside of concrete or mortar before it is set, a corresponding amount of cement will, of course, not harden and the work will consequently be that much weaker. Besides this, effervescence will, as a rule, set in. The cause of this phenomenon is that there has not been formed enough hydrogel on the surface especially to enclose the precipitated lime or fill the spaces between the grains of sand before the moisture is taken away. When, then afterwards water gets access to such a piece of work it will, when evaporating, carry the dissolved lime to the surface and there deposit the same. This could not have occurred if there had been enough mineral-glue, as the latter is waterproof.

The last stage of the hardening progress of Portland Cement is now finished.

Before leaving the subject I may add that there seems to be a tendency to ascribe both the strength and the hydraulic properties of Portland Cement to the hydrogel or gel alone. I do not, however, think that this view is justified. Why is it that a sound Portland Cement high in lime makes stronger mortars than one low in lime? It is more probable that the Ca (OH_2) crystals, besides being able to take up direct compression, by filling up the cavities in the hydrogel, act like struts in a trestle, *i.e.*, stiffen the comparatively thin cell walls.

The actions of the hydrogel may be summed up as follows: This practically insoluble substance prevents during the hardening process the escape of the lime on account of its semi-permeability and after the cement is set it makes it waterproof and in combination with the crystals of hydrate of lime, of calcium-hydroaluminate and calcium-hydro-ferrite gives it the strength.

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THE COMMERCIAL ASPECT OF CONCRETE IN CANADA

BY GUSTAVE KAHN.

That concrete as a building material has passed the experimental stage in modern construction is evidenced by the rapidly increasing number of structures to be found in the civilized world.

Writers of history tell us that concrete, either plain or reinforced, is not a new material, and in support of this statement point to structures of ancient as well as medieval days. Be that as it may, our own immediate knowledge of the material is comparatively new, but new or old the data to be had relative to the material and its value as a structural material, is to-day just as complete and just as reliable as the data to be had on any other material.

The history of mankind divides all epochs pertaining to civilization into different ages, and so we may safely conclude that the history of construction should be divided into ages. We have had the age in which stone was used, we have had the age in which wood was used, and we have had the steel age, but we are now passing through what in time will come to be known as the concrete age. That the concrete age will occupy just as prominent a place in future building history as any other is only reasonable to expect, even though the conditions making this possible have changed.

As Victor Hugo has said in his writings: In early history structures of all classes were intended to record the happenings of the day; in other words, to record history. Therefore, in order for a material to be adopted for structural purposes its main requisite was quality to withstand the ravages of time.

To-day we look for more. In order that a structural material satisfy the required demands it must have the enduring qualities required in earlier days, and also must have the virtue of being easily handled in order that it may be commercially economical in its application. This then is the primary reason why concrete will naturally come to be known as the building material of the age. There is no known material that will better withstand the ravages of time, and, furthermore, there is no known material that can be handled more economically.

That Canada is keeping pace with other countries in concrete construction is evidenced by the growth of the entire industry in Canada. Unquestionably the best indication of the industry's growth is recorded by the cement manufactured in, and imported into Canada. Looking into this record we find that during the year 1900 there were manufactured here 292,124 barrels of cement. During the same year there were imported 374,966 barrels of cement. This shows that the total consumption for the year in Canada was 667,090 barrels, of which only about 45 per cent. was manufactured here.

During 1909 there were manufactured in Canada 4,089,191 barrels; there were imported 156,456 barrels; the total consumption for the year being 4,245,647 barrels, with the splendid showing that a total over 95 per cent. was of home manufacture.

The fact that concrete work in Canada compares favorably with concrete work in other countries indicates that the cement manufactured here compares favorably with that manufactured in other countries.

Assuming that as an average there is used one and a quarter barrels of cement to each cubic yard of concrete, we have for the year's work 3,396,500 cubic yards, representing an approximate expenditure of $30,500,000 for the year.

There is cause for congratulation among Canadians that more than eighty per cent. of all the materials entering into this work were produced in Canada. And I believe that the growth of the industry is such that we are justified in demanding Government recognition of the industry.

I believe that it will be of a special interest to this convention to hear that practically all of the important structural work in Canada during the last year was either entirely or partially carried out in concrete, plain or reinforced. This statement may be rather broad, but can easily be proven.

A hasty review of the situation may not be out of place at this time. To make the review systematic we would begin at the Pacific Coast.

The largest building in Victoria for the year, known as the Pemberton Building, is reinforced concrete throughout.

All of the larger buildings in Vancouver for the year are either entirely reinforced concrete or are steel skeletons with concrete floors.

Coming on to Calgary, there were erected last year in this city two large reinforced concrete buildings, in addition steel frame buildings with concrete floors.

Edmonton has been backward, the use of concrete there having been limited to foundations and concrete floors.

Regina, on the other hand, was one of the leaders in this class of construction. The most notable examples there are the Saskatchewan Parliament Buildings, almost entirely of reinforced concrete.

Winnipeg was easily the leader. There may be found the Transcontinental Railway shops, almost entirely of concrete, the Fort Garry Terminal Station having steel frame, concrete floors, the Maltese Cross Rubber Co. Building is a very large reinforced concrete warehouse; the Government Examining Warehouse, steel frame, concrete floors, and so on. We learn that Winnipeg alone was responsible last year for about thirty large concrete buildings, not counting the smaller work to be found everywhere. Then there was the large Power Plant for the City of Winnipeg at Lac Du Bonnet, almost entirely of concrete.

We next come to Port Arthur and Fort William. The largest grain elevators in these towns were erected last year in reinforced concrete.

Coming still further east, for the year right here, in and around London may be found any number of good examples of concrete buildings and bridges. Among these may be noted a building finished for the Murray Shoe Co. Also may be noted the water works and power plant now in course of construction.

We next go to Hamilton; there nearly every building of importance erected during the past year is either entirely or partially of reinforced concrete.

Toronto was a little behind, though it also shows its quota of good work for the year. The fight in Toronto last year in connection with the large trunk sewer there, now in course of construction, should be of especial interest to this Convention. The engineers for the work designed it originally in concrete. The brick industry made a very strenuous fight and succeeded in delaying the awarding of the contract. Through them the City Engineering Department was compelled to investigate concrete for sewer construction in general, and only after a very thorough investigation were they permitted to adopt concrete.

During 1909 in Peterborough there was erected a large water works dam and power house. They also started there, last fall, the most important concrete arch bridge yet attempted in Canada.

Belleville and Kingston are well represented in this year's work.

Ottawa shows five new reinforced concrete buildings as well as a large concrete grandstand built on the Fair grounds.

Note here, that in giving the number of reinforced concrete buildings, the numerous smaller buildings erected in this material have not been included.

In Montreal was erected the largest reinforced concrete building in Canada during 1909. The structure to which I refer is known as the Jacobs Building. It has a frontage of 237 feet, a depth of 133 feet; at present it is seven stories high, and is planned to eventually be increased to ten stories. Another example is the Wilder Building, a ten-storey warehouse. Another, the Ogilvie Building, a large steel skeleton frame with concrete floors. In addition to these Montreal has a number of smaller buildings erected in concrete during the past year.

And so we may pass on to the Atlantic Coast, and find evidence to substantiate the claims made earlier in this paper.

The commercial success or failure of the contractor in concrete work is entirely a matter of ability in handling the work efficiently. No *greater mistake* can be made by the contractor than to attempt to make money on concrete work by slighting or skimping the job. Only the best materials obtainable should be used. It is true you may place a certain amount of stone, sand and cement into a mixer, mix it and place it in position to harden or solidify. A satisfactory piece of concrete may be the result, but if it is, it is merely a matter of chance. On the other hand, if proper precautions are taken, if the stone is clean and of proper quality and size, the sand clean and of consistent quality, the cement sound and of recognized quality, the proper proportions of materials carefully mixed together, the total just as carefully placed in position, there can be no question as to the result. It is a foregone conclusion, not a matter of chance. And so if the contractor is working on reinforced concrete work it is necessary to exercise the same precautions. It is not sufficient to place steel into a bed of concrete and then run chances of the amount, the quality or shape of steel being right. There is only one proper way, and that is to analyze or diagnose the case. Be sure that all possible conditions have been considered, such as the known load that the structure is to sustain, the greatest possible load that it may be called upon to sustain. Analyze the stresses these loads will produce on the concrete as well as on the steel, make sure that the quality and quantity of the concrete as well as steel is sufficient to take care of this load. Make sure that the concrete will be called upon to take care of only the stresses it is known it can resist (compression). Be sure that the distribution of the steel throughout the mass is in accordance with the stresses distributed throughout the mass. In other words, be sure that all compression, all tensile, as well as all shearing stress are provided for. Then exercise the proper precautions in combining the proper materials, and the final result is again a foregone conclusion, not chance; it spells success.

No contractor can become a permanently successful business man unless he does good work, and at the same time makes money. It therefore only follows that a successful concrete contractor must do good concrete work, and must make money.

According to my former statements, if all necessary precautions are taken in designing, planning, inspecting and performing the work, the final result cannot be questionable. The only thing that remains to be considered from a business point of view is how to make money. To this there is only one answer. Learn to figure costs. Do not undertake a contract unless you can see that the price to be obtained will provide a profit. It may seem strange but it is true that the differences of opinions among contractors regarding cost are just as great as the differences of opinions among lawyers, regarding matters of law, or doctors pertaining to matters of medicine. Only careful study and long experience will perfect the contractor's judgment in this regard.

There are always, however, or should be, certain positively known facts. They are, the cost of the required material, the cost of transporting these materials to the site, the overhead charges, or cost of looking after the routine business in connection with any contract. Then comes the cost, or probable cost, of equipment required, and last but by no means least, rather the greatest, is the cost or probable cost, of the required labor. If the plans are properly prepared the cost of the materials is usually only a matter of plain addition and multiplication. Right here, I would ask you to observe that this statement is modified. The plans must be properly prepared, and that means a lot. For plans to be properly prepared, they must show the most economical known way to accomplish certain results. By this is meant that every particle of material shown on the plan must, when incorporated in the work, perform a certain needed function in such a manner that the full strength of the material used is developed; and further, that only materials especially suited for certain functions be employed for said duties. The statement has often and truly been made that every dollar judiciously spent in planning work will save two dollars in performing same. This principle also holds true in the careful selection of the materials to be used. Usually speaking, the low unit cost of raw material is not a criterion of careful planning, for, should all materials required in a structure cost the contractor $10.00 and the labor required to place this material into the structure cost an additional $10.00, the result in total cost being $20.00, then if differently prepared materials will cost $12.00

and the required labor in the latter case cost $6.00, the second material is unquestionably more economical and the engineer who prepared the plans showing these materials has proven his right to his title. The overhead charges in any business are usually the result of business system; the better the system employed the lower the cost of the result obtained. The cost of labor is usually reduced in direct ratio to the care exercised in planning the work, selecting the materials and selecting the equipment for handling.

To sum up, to be successful as a contractor in concrete work, plan the work in a careful manner, select carefully the material to be employed in the work (employing not the materials whose first cost is lowest but materials that are most economical in place and when properly prepared reduce the chance of error to a minimum). Simplify as much as possible field labor and above all things refrain from taking contracts so low that when the work is finished and the bills are paid, nothing remains to recompense you for the energies expended in carrying the work to completion.

We are all working, or should be working, for a common cause, the success of the cement and concrete industry. Remember that every bad piece of concrete work done injures not only the contractor who performed this work, but the entire industry, so for this selfish reason, if for no other, it is up to us to assist one another in successfully handling all our contracts. In our interest we cannot afford to knock, we must boost our fellow-concrete contractor.

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WHAT THE CONCRETE BLOCK MEANS TO CANADA.

BY J. AUGUSTINE SMITH.

The development of Canada carries with it tremendous potential possibilities in every direction. In this development I know of no one factor that will be of greater real benefit to you than the concrete block. When I speak of the "Concrete Block" I do not mean the poor, cheap, porous cement block you see frequently, but rather the well-made, dense, sound, impervious stone, that is of first-class quality, and meets every requirement; the product that secures the unqualified approval of the architect and builder.

The statement that the concrete block is destined to play so important a part in your affairs may be questioned by those who have given the subject but casual thought or observation. Let us, therefore, give some consideration to this subject.

In the first place, I take it, your history of development will very closely resemble the methods, means and characteristics of the development and growth of the United States when our great West was being peopled. Great colonies poured in, habitations were rudely and hastily erected, with all the waste and destruction consequent upon the necessity of providing living quarters quickly. In such a rush, the great desire was to build as cheaply as possible, without regard to economy or the real necessity for the promotion of safety. The result was a wooden building era, which has cost us millions upon tens of millions of dollars, hundreds upon thousands of lives, and has given us a character of building which has proven extraordinarily costly, and has threatened in a serious way the prosperity of our country. Indeed, it is this phase of the question that I want to bring strongly before you, and upon which I want you to give serious consideration.

In our history the greatest drain we have had upon our resources is our constant and extraordinary loss by fire. This is due to our loose and insecure methods of building construction. We have built of wood, sufficient for to-day only, and without regard to permanence. Our experience in this respect should be preventive of your making the same mistake.

Most people are unaware of the extraordinary loss we suffer each year by fire. This matter is now receiving the careful and earnest thought of our people. The United States Government have lately established, under the Department of the Interior, structural material, testing laboratories at St. Louis for the purpose of determining the character of all structural materials, as well as their fire resistive properties.

As illustrating the importance of this investigation I may call your attention to the fact that the fire loss in the United States, including not only property destroyed, but the maintenance of fire departments, payments of insurance premiums, so-called preventive agencies and other incidentals, amounted to over five hundred million dollars in 1906, or over 80 per cent. of the value of the total new building construction. This is equivalent to an annual tax of over six dollars per capita. By comparison, in six of the large European countries, the fire loss averaged only thirty-three cents per capita, and this in spite of the fact that the appliances and facilities for fighting fires in the United States are greatly superior to those in European countries.

The advantage shown in the fire losses of other countries is due to the more extended use of building materials which are more or less fireproof.

The laboratories above referred to have carried on a series of tests to prove the relative value of the structural materials in resisting fire, and the report of these series of tests carried on has just been issued by the Government, and it shows conclusively the extraordinary value of concrete blocks in this regard.

A short time ago I saw a very able article in one of the magazines, which went on to say that the proper way to reduce the loss by fire was to prevent it. A wiser statement never was made. Canada, therefore, has it within her own province to recommend and devise methods for the prevention of the tremendous drain caused by fire losses such as we have experienced on our side.

Let me show you a little more clearly just what the United States suffers annually from this one cause of waste. The annual fire expense in our country, as I have said, has reached in some years the enormous sum of five hundred million dollars, with a death list of seven thousand persons. This property loss represents a loss that does not include the loss of profits to the business man who has been burned out for the time he is out of business.

In foreign countries there is an average loss of less than one fire per year to every thousand of population, while in the United States we have four and a half fires per year for each thousand population. Natural conditions are, however, conspiring to bring about a change in this regard. The increased cost of combustible building materials has made us look for something else, and this has called public attention to the extraordinary fire resistive qualities of concrete.

An active movement has been started to secure fireproof construction, especially in our public buildings. To-day there is scarcely a city of any size where there is not a strong sentiment in favor of fireproof construction for all public or semi-public buildings. How little has been accomplished, however, is shown from the fact that with some twelve million buildings in the United States there are only eight thousand which are even so-called fireproof, while, in all probability, two thousand will cover the number which are actually fireproof.

While the largest proportion of our fires occur in dwellings yet there is an average weekly destruction of three theatres, three public halls, twelve churches, two hospitals, two asylums, two colleges, twenty-six hotels, three department stores, six apartment houses, two jails and sixteen hundred dwellings.

The press, usually alert and active in all our great reforms, has taken up this question of loss and waste by fire, and is doing effective work in calling the attention of the public to the necessity for better construction. This agitation has, in a measure, accelerated the manufacture of building materials that are best calculated to form the greatest resistance to fire. This is most noticeable in the case of Portland cement and cement products, and particularly in the rapid development and use of concrete blocks and reinforced concrete.

Only the other day I saw a notice in the paper where one of the finest, largest apartment house buildings in the world was partially destroyed by fire in New York. It was thought to be a thoroughly fireproof building. I have no doubt, without knowing it actually, that it was constructed of steel and hollow tile. Hollow tile construction is not fireproof construction, and the sooner we come to a realization of this important fact the sooner we will inaugurate better methods of preventing great fire loss.

Whenever the expansion and contraction of steel and its protective material is unequal, there is bound to be a breaking away of the fire protected material, with the result that the fire gets to the steel and the columns, beams or girders buckle and are destroyed.

This subject of fire loss means much to Canada. Your country is growing, and growing fast. It is incumbent upon you to develop the means by which you will prevent making such economic mistakes as we have made.

The first requisite is to see that a proper, fair building ordinance, of an intelligent character is passed in each of your cities and towns. Do not attempt, however, to build your ordinance on some of the silly ordinances which have been passed in the United States. In passing some of these ordinances which I refer to, influences were at work to favor certain forms of building materials, to the exclusion of others. Indeed, in a certain notorious case, the mayor of a great city was hastily summoned from his vacation in the mountains to veto a city ordinance that had incorporated in it a provision which would effectually prevent the use of certain building materials to the exclusive benefit of certain other materials. The mayor vetoed this ordinance, demanded that fair provision be incorporated in the measure that would make for the safety and protection of the people in their rights, and at the same time secure equity and fairness for all.

Then, too, it sometimes happens that the ignorance of the extraordinary character of concrete in strength has led the makers of some of these ordinances to require an excessive width of wall for ordinary building purposes.

It is clearly recognized on our side that an 8-inch concrete wall, whether it be of monolithic or hollow block construction, is sufficient for all buildings up to two stories in height. Indeed, the common practice is to permit the substitution of an 8-inch block or monolithic wall, where 10-inch or 12-inch brick walls are specified.

The extraordinary, inherent, compressive strength of the material, makes this good practice. There is reason in all things, and I sincerely hope Canadians will see to it that they do not go to the opposite extreme in seeking to secure permanence of construction. It is easy to waste money in excessive requirements, just as it is to err in not taking sufficient precautions to secure the best results. When due regard to the common factors of safety necessary to produce permanence is taken, anything more than that is an extravagance.

I therefore hope that in drawing your ordinances and in seeking to secure what I strongly recommend, i.e., safety and permanence of construction, due consideration will be given to provisions that will protect the builder as well as the public.

The peculiarly fitting character of concrete to Canadian resources is well known. It is a fact, I believe, that while you have extraordinarily fine forests and splendid deposits of stone in certain sections, there is a wide section of your country that is devoid of structural materials, but which is blessed with gravel and sand of a splendid character. Moreover, that you have deposits of limestone and marl that make it possible for you to produce cement in unlimited quantities.

This means you have at hand everything necessary for the production of concrete of the highest grade, that will enable you to build with great saving to yourselves, and at the same time secure absolutely fireproof structures at low ratios of cost.

Moreover, I believe Canada is to be congratulated because of the fact that, in the development of the concrete business, the manufacture of concrete blocks has not been productive of the extraordinary amount of poor work so frequently seen in the United States; in other words, you have been a little slower to take hold, but your disposition is to produce good work. With us a lot of small people engaged in this industry in the beginning, without proper financial means to carry the business on, and without the proper business training to make it a success.

This condition is being rapidly changed, however, and now people of large means, thorough business training, and with qualifications fitting them to carry on this industry in the best possible way, are now engaging in the manufacture of concrete stone, with the result we see evidences on every side of the adoption of concrete in this form in the building of large structures, and in its use in combination with reinforced concrete and steel building operations.

What has happened on our side will happen with you. You have this distinct advantage, however, your patent laws are a little better enforced than ours, which has prevented the influx of cheap, crude machinery for the production of concrete blocks, and I have no hesitation in saying to you that the cement block, properly made, will be one of the greatest economic assets you will have in your building operations in Canada.

I take it, also, in Canada fewer mistakes have been made than with us, for it has been remarked to me many times that the business is in a position to develop naturally, along the most approved lines, with machinery and appliances convenient to do the very best work possible.

I therefore say with confidence that the development of the concrete block business in your country should be coincident with your prosperity and development. Good concrete blocks cannot be produced without proper methods of manufacture, and it is essentially necessary that careful supervision and scrutiny be exercised by your public officials to see that this material is made worthy to be used in all kinds of construction.

The saving to be made, by reason of the use of cement blocks is extraordinary. Without any hesitation whatever, therefore, I say you will not only save millions and millions of dollars in the first cost of construction, but you will add to this constantly, by reason of the permanence of your buildings and their fire-resisting quality.

Of all the drains and waste you may be threatened with, there is none that is so vital, so useless, and so easily preventable, as that of fire. An ounce of prevention, in this regard, is easily worth ten pounds of cure.

Concrete blocks are now being produced of the most artistic and beautiful kinds.

The development of this industry has gone forward until architects and builders have come to realize that concrete in unit form is destined to play a very important part in all future construction work. Under a process lately developed, blocks are now made that are absolutely impermeable to moisture, dense, sound and durable as time itself. Blocks are made with faces of granite, marble, limestone and other effects, as well as being produced in a variety of colors that lend themselves easily to any scheme of color decoration.

Indeed, the development of the concrete block has reached that point that one of our great millionaires in the United States is building a country residence constructed entirely of blocks that will be one of the finest and most palatial country seats in the United States. To give you some idea of what he is doing I may say he has already built a massive residence for himself, a large cow-barn, piggery, dairy and power house, and purposes building in all sixteen residences, twelve large barns, four 50-foot silos, a power house, chicken houses and other buildings, as well as four miles of concrete fence which will take in all more than one million concrete blocks. In this work alone, more than twenty million brick will be displaced.

This will give you an idea of the manner in which concrete blocks are now being used on our side.

Now, as to the comparative cost of good concrete block construction as against other forms, I stated to you in a paper I read before your Convention last year, some of the costs which this form of construction made possible. Since that time, in the development of automatic tamping machinery, loading and trowelling devices, and the incorporation of modern, up-to-date methods in the concrete block plant, these costs have been materially reduced.

The company I have the honor of being connected with has found necessary the development of modernly constructed plants, built upon economical lines that will enable the manufacturer to produce his manufactured product at the lowest possible cost of manufacture and of labor, by reason of the perfect installation of his machinery, and the layout of the plant, designed with the idea of securing true, economic results.

We have devised 120 different types of plants for the manufacturer to select from, ranging from the automatically equipped plant, in which everything is done by machinery, down to the one-machine, one-man plant, in which everything is done by hand.

Moreover, we have carried along a series of tests to demonstrate the necessity for a proper grading and selection of the aggregate used. This is a very important item, so important, indeed, that we strongly urge the assaying and rectification of the aggregate used in manufacturing blocks, so as to secure the greatest possible saving in the cement necessary to bind the whole into a concrete mass.

Furthermore, we have found it necessary to go into a series of tests that will demonstrate the exact amount of water necessary to use to produce the best results, and we have found some astonishing features in the tests so far carried on. It will require about eighteen months to complete this investigation, and I feel I can say we will be prepared at the end of that time to give to the concrete world results that will prove of great benefit to the manufacturer of concrete blocks.

In closing, I wish to say that the development of this industry in Canada is a very vital subject with you, particularly in the development of the business on proper and rational lines. If this is done I believe you will agree with me, in the course of the next few years it will represent a material advantage to you in the saving and economies it will secure in the use of the concrete block as a building material.